A Quarterly Journal for
Teachers of Science in
the Catholic High Schools

VOLUME II
NUMBER 4
DEC., 1936

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For Your Attention . . .

In other places in this number certain educational opportunities are offered nationally for the first time to science teachers and to the pupils in their classes. High school instructors all over the United States will take advantage of these aids to good teaching.

- In the science essay contest, students in small village high schools have an equal chance with those in the larger schools in cities to gain nation-wide recognition for themselves and for their schools. To enter the contest costs nothing; it means only extra time and labor. Teaching Sisters and their pupils are not afraid of work.
- The interesting science project material that has been displayed at the Duquesne University Conferences in recent years has shown graphically the splendid work in science that is being done in some of our schools. This year's exhibit should surpass all others, since for the first time the loan of projects is solicited from other than local schools. What are your pupils doing in science?
- We know of no other activity that can do as much for the school, the pupil, and even for the teacher, as an open-house Science Night. Teachers and administrators should consider carefully Mr. Collier's article in this number. Careful planning is necessary, and much work is involved in conducting an affair of this sort, but after it is over teachers always approve it enthusiastically as one of the most interesting and valuable helps they have ever used. Why not try it?

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Steps Forward . . .

●

A NATIONAL ESSAY CONTEST

At last there is to be a *national* essay contest for Catholic high schools!

For a number of years at its annual spring Conference for teachers of science, Duquesne University has sponsored a prize essay contest for students enrolled in the Catholic high schools of the Pittsburgh district. Each school submits one essay on an assigned topic of a scientific nature. The essay entered in the University contest is usually selected as a result of competition among the students in the individual school.

Up to the present time only schools in the ten dioceses close to Pittsburgh have been invited to participate. The suggestion has come repeatedly that the contest should be more inclusive, that it should be a national affair, and that all Catholic high schools everywhere should be allowed to compete. The idea seems to have merit. There appear to be good reasons for extending the contest, as well as others that might seem to make the change inadvisable. After considering the matter carefully for some time, the officers of the University have decided to make the annual essay contest national in scope, and to invite the Catholic high schools and junior high schools of the whole United States to submit essays.

This is the first formal announcement of the national contest. *It is an official invitation to all Catholic high schools which teach science, to participate.* Special invitations will not be sent to individual schools. No further announcement of the contest will be made. This is an invitation to *your* school. It is expected that entries will be received from dozens of schools in all parts of the country. Progressive teachers will use this nation-wide contest to stimulate student interest in science. Winning the contest will be a distinguished honor, one that will reflect credit upon both the student and the teacher. It will bring prestige to the school.

The essays submitted in this competition will be judged by members of the faculty of Duquesne University. Form, content, and expression will be considered. A gold medal, for permanent possession, will be awarded to the writer of the best essay. One or more honorable mentions will be made, depending upon the excellence of the essays submitted. A suitably engraved silver cup will be given to the winning school. The cup will be held for one year. It will then be passed on to the school receiving the new award.

Announcement of the winner will be made at the next annual Conference for teachers of science which will be held at Duquesne University on February 20, 1937. The prize essay will be published in full in the SCIENCE COUNSELOR. Only winning essays and schools will be announced. A list of the schools which enter the contest will not be published.

Schools which expect to submit essays in this contest should so inform the Director of the Science Conference, Duquesne University, Pittsburgh, Pa., by letter or postcard, on or before January 1, 1937. No obligation is incurred by sending such notice.

The rules which are to govern the contest are here given.

RULES FOR ESSAY CONTEST

Subject of the Essay: *Air Conditioning the Home.* No other subject may be used.

1. Any student enrolled in a Catholic high school, junior high school, or preparatory school, who has not yet completed four years of high school work, is eligible to enter this contest. It is not required that the student shall be enrolled at present in any science course. Catholic students attending public high schools may not compete.

2. Each school may submit *only one* essay.

3. Essays should be typewritten, double-spaced, with good margins, on one side of the sheet only. Legible hand-written manuscripts may be accepted. Essays are to be in essay form. They may not exceed 1,200 words in length. Longer essays will be rejected without reading. All direct quotations must be inclosed in quotation marks and references given. Long quotations are not acceptable. Essays may not be illustrated nor accompanied by charts or exhibits.

4. Each essay shall be the individual work of the student. In its final form it may receive only such supervision as is given in the usual written examinations of the school.

5. A plain, sealed envelope, firmly attached to the essay, must contain the full name, age, and home address of the contestant, the actual number of words in the essay, the name and address of the school, and the name and title of the supervising teacher. No further identification of the writer or the school may appear on the essay or the envelope.

6. Essays must be forwarded by the principal or the supervising teacher with the statement that the essay was written under supervision and that it is the original work of the student.

7. Essays for this contest must be mailed to the Director of the Science Conference, Duquesne University, Pittsburgh, Pa., not later than *February 1, 1937.* Essays will not be returned.

●

SCIENCE CONFERENCE

Teachers everywhere are invited to attend the fifth annual one-day Conference for teachers of science in the Catholic high schools, which will be held at Duquesne University on Saturday, February, 20, 1937. Early announcement of the date is made so that teachers may have plenty of time to make plans for participating.

As he has done so graciously in the past, the Most Reverend Hugh C. Boyle, Bishop of Pittsburgh, will again address the Conference. The Superintendent of

Continued on Page One Hundred and Thirteen

Selecting Chemicals

For Laboratory Use

● By E. S. Russell
CAMBOSCO SCIENTIFIC COMPANY, BOSTON, MASS.

Frequently, the teacher who knows how to order chemicals properly is able to save considerable money for his school.

How many teachers know that there is now no standard 8 oz. package? Or the increase in cost that may be caused by the often unnecessary injunction "all chemicals must be C.P." Or the importance of using complete, unabbreviated, chemical names?

Mr. Russell makes some money-saving suggestions.

●

In the purchase of chemicals for the high school laboratory it is equally possible to spend more money than necessary, and to "save money" on materials utterly unfit for their intended use. The happy medium is attained by careful attention to three all-important factors: *quality, identity* and *purity*. Each of these has a decided influence on cost as well as on experimental results. Incidentally, the exact indication by the purchaser of the amount, kind and grade of chemical wanted goes far toward assuring the accurate filling of orders.

Quantity

American manufacturers of chemicals have adopted four standard sizes for their "small package lines." They are: 1 oz., 4 oz., 1 lb., and 5 lbs. Since there is now *no* 8 oz. package, orders for that quantity are filled with two 4 oz. units or with a 1 lb. package when, *as is frequently the case*, the latter can be supplied at the same price.

For laboratory use, the three mineral acids and ammonium hydroxide are furnished in "five pint acid bottles" (of which ten constitute a standard case), and in carboys of two sizes. The net weight of a "five pint" bottle of ammonium hydroxide is 4 lbs.; of hydrochloric acid, 6 lbs.; of nitric acid, 7 lbs.; and of sulfuric acid, 9 lbs.

The purchaser of any chemical pays, directly or indirectly, not only for the reagent itself and for a suitable container, but also for the labor of filling, weighing, labeling and packing in accordance with the requirements of the Interstate Commerce Commission. The cost of a one ounce bottle may be more than that of its contents. The labor burden chargeable to a 5 lb. package is little more, if any, than for a 1 lb. unit. There is real economy, then, in the purchase of standard packages of a size large enough to supply the needs of a year.

Identity

Many common chemicals are available in more than one form. The hydroxides of sodium and potassium, for example, are now manufactured as small pellets (average weight about 15 cg.) which are far more convenient, but no more expensive, than the cumbersome sticks.

With or without price increase, the utility of a given reagent may be in part determined by three purely physical factors:

1. Size e.g., Lumps, Granules, Crystals, Powder, Precipitate.
2. Shape e.g., Sticks, Cubes, Pellets, Scales, Flakes.
3. Condition e.g., Dry, Anhydrous, Absolute, Glacial, Syrupy.

When the catalog listing offers a choice of size, shape, or condition, the desired form should always be indicated.

Of greater importance than form, however, is accurate designation of name. For some reagents, there are several scientific synonyms. Their common names are legion. Slight differences in nomenclature may mean vast differences in results. It is obvious that between mercurous chloride (a valuable medicine) and mercuric chloride (a violent poison) the difference may be one of life or death.

In the interests of definiteness, resort is sometimes had to chemical formulas which, when correctly written, should leave no room for doubt. Unfortunately, however, the formulas with which science teachers have familiarized themselves through daily use are as incomprehensible as hieroglyphics to clerical workers by whom requisitions and orders are transcribed. The obvious opportunity for error in copying unfamiliar symbols is magnified by the coincidence that, on many typewriters, the lower case L and the figure 1 are represented by the same character. For the sake of safety and satisfaction, all reagents should be listed by their complete, unabbreviated chemical names.

Purity

As applied to chemical compounds, purity is a relative term. Each forward step toward the goal of absolute purity (which, like absolute accuracy in the realm of measurement, can only be approached as a limit) gives rise to one or more grade designations.

There results a multiplicity of trade terms—sometimes confusing to the uninitiate—which may be divided into three important grade groups, fairly defined as follows:

Group I.	Tech. Com'l	The technical, or commercial, grade. Free from foreign materials and gross impurities, but not purified to standards that are either constant or predetermined.
Group II.	U.S.P. N.F.	With impurities not exceeding the close tolerances established, for medical use, by the United States Pharmacopoeia or the National Formulary.

Continued on Page One Hundred and Twenty-four

The Aquarium,

A Project in Biology

● **By William A. Helfrich, B.S.,** *(Duquesne University)*
PUBLIC HIGH SCHOOL, TITUSVILLE, PA.

High school pupils always are interested in building things. They like to care for water animals and plants. Here is an opportunity for them to do both.

This teacher has been successful in inspiring his students to undertake the work of building aquariums and in carrying it to successful completion. He tells you how it is done. Why not try it? It is a good way to interest parents in the work of the school.

Later Mr. Helfrich will describe the building of fish ponds and turtle pools.

●

Every year when school opens in the fall our pupils show a great deal of interest in the several home-made aquariums we maintain in our biology laboratory. They want to know how to build them, how much they cost, which plants and fishes will live in them, and how often the water must be changed. So many of their questions are worth while that we have collected the queries and use them as the basis of a student project which we call

THE AQUARIUM

1. Of what use is an aquarium?
2. Can we build one for ourselves? What will it cost?
3. How much water do aquariums hold?
4. How can we determine the dimensions to use for a tank of given capacity?
5. How often should the water be changed?
6. How much sunlight is needed?
7. Why do the sides of some aquariums become coated with green scum?
8. What kinds of plants are used? What are their names? Does it make a difference how they are arranged?
9. What animals will live in an aquarium?
10. Will goldfish spawn and develop in an aquarium?
11. To what diseases are goldfish subject? How should the diseases be treated?
12. Can we prepare our own fish food?

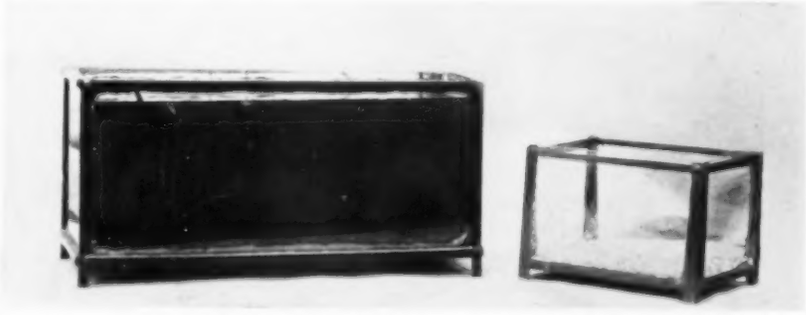
Investigations of the accessibility and cost of materials, and of the tools and skill required, show our pupils that the building of an aquarium is not beyond their capabilities. In practice, we have found this to be true. Students of high school age are able to do a very creditable job. We have built a considerable number of aquariums of several different sizes ranging from one to twelve gallons. One of medium size holding about six gallons has proved to be the most popular.

The question of size and capacity provides a problem in arithmetic. We must calculate what dimensions we shall use for a six-gallon aquarium. We know that there are 231 cubic inches in a gallon. With that information as a starting point we are able to determine that a tank 21"x 9"x 8" will have approximately the capacity we desire. We learn that we can change the length, width, or height, and by making corresponding variations in the other dimensions still have an aquarium of the same capacity.

Our directions for building work out about like this: From a piece of one-half inch "angle iron," bought at a hardware store, cut four pieces 21" long, four pieces 9" long, and the same number of pieces 8" long. If legs are wanted, the 9" pieces should be made one inch longer. We have learned, however, that until experience in construction has been gained, it is better to build tanks without legs. The ends of the 8" and 21" pieces that are to form the top of the aquarium frame are cut slanting on one side at an angle of exactly 45° so that when the frame is assembled the corners will be true right angles. The same procedure is used for the bottom frame. Two ⅛" holes are drilled, ¼" from the end, in each end of each piece, except where the ends have been cut slanting. The position of the holes is first marked with a punch. A ⅛" drill is used. Students sometimes build a frame out of stiff paper before they begin work with actual materials. Such a procedure prevents annoying mistakes. We recommend it.

The frame is now assembled and held together temporarily by means of small bolts and nuts. Accuracy in the pupil's work or the lack of it now becomes apparent. Bolts from the assembled frame are removed, one at a time, and replaced by soft rivets, ⅛"x⅜", which are riveted into place. The frame is now ready for painting. When students are allowed to select their own colors, amusing combinations are sometimes chosen, but generally a plain green or black is used. Any quick drying paint will do.

While the paint is drying, glass is cut for the sides and bottom. Slate may be used as a base for the larger



HOME-MADE AQUARIUMS

THE SMALL AQUARIUM ON THE RIGHT HAS A FRAME MADE OF GALVANIZED IRON.

aquariums, but glass is satisfactory especially if the thick strong glass such as can be obtained from the windshields of old automobiles is to be had. A visit to an automobile junk yard will be worth while. If heavy glass of this kind is used, it is necessary to use ¾" angle iron for the frame. In measuring ordinary glass for cutting, dimensions of about ⅛" less than the frame are used to allow for the cement that will hold the glass in place.

A satisfactory cement is made by mixing together thoroughly the following materials:

White Lead	4 oz.
Red Lead	1 oz.
Chalk	8 oz.

Linseed Oil, enough to form a putty-like paste.
Powdered charcoal or lampblack is added if a black color is wanted.

Fitting the glass into the frame requires time, patience, and some experience in order to produce good results. First, place on the lower frame a layer of cement, 1/16" in thickness. Spread it evenly and press the bottom glass down upon it. Then, after applying cement to the side frames in a similar manner, set in the end pieces, and, finally, the side glasses. *Insert the pieces of glass in the order given.* Apply more cement wherever it is needed, especially where glass contacts glass. Scrape away the excess so as to leave neat joints.

The finished aquarium must stand undisturbed for some hours to allow the cement to set. It is then filled with water which is allowed to remain in it for at least two days so that any soluble materials in the cement that might be injurious to plant or animal life will be dissolved out. If cement is squeezed out by the pressure of the water, it should be scraped away. The tank is rinsed several times with fresh water. It is then ready for use.

Aquariums of small size may have a frame made of galvanized iron rather than of the stronger angle iron. Galvanized iron is easily cut, bent and drilled by any plumber. It is inexpensive. The cost of the larger tanks made with angle iron is not great. One of six gallon capacity can be made for less than $1.50. The expense might be approximately as follows:

Angle Iron	$0.20
Rivets and Bolts	.06
Paint	.05
Glass	.60
Cement	.50
Total	1.41

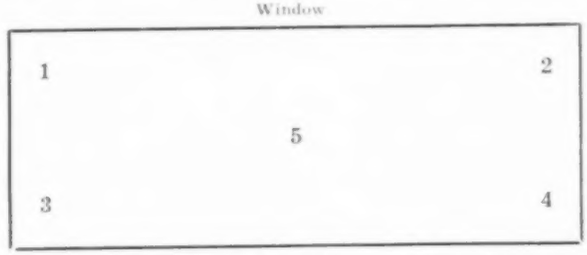
When usable materials such as glass and paint are already on hand, and when several tanks are built at one time, the cost is still further reduced.

Planting the Aquarium

We cover the bottom of the aquarium with about one and one-half inches of gravel or sand that has been thoroughly washed. We then plant three or four strands of any or all of the following plants:

1. *Anacharis* or *Elodea* (water weed). Bunched plants that grow rapidly in a well lighted aquarium. It is used in laboratory experiments to show the movement of protoplasm, and to prove that plants give off oxygen.
2. *Cabomba* (fish grass). A decorative plant. It has finely divided leaves that are fan-like in appearance. Not hardy. Fish pick it to pieces. Furnishes food and oxygen.
3. *Myriophyllum* (water milfoil). A plant of marked individuality. Requires plenty of light. Of value in the spawning of fish.
4. *Ludwigia* (swamp loosestrife). Prized for its graceful appearance. Has a crimson or pink color on the underside of its leaves. A great oxygenator. Thrives in a well lighted tank.
5. *Sagittaria Natans.* Tough dark-green leaves. Furnishes much oxygen
6. *Sagittaria Sinensis* (giant arrowhead). Broad blunt submerged leaves. A good oxygenator.
7. *Lemna* (duckweed). A very small seed plant with water roots. Multiplies very rapidly. Eaten by some fish.
8. *Piaropus* (water hyacinth). Needs plenty of light. Serves as a resting place and shelter for animals. Flowers early in the spring. Roots are used as food.

The first four plants mentioned must be weighted with lead foil or small stones in order to keep them in place. A little of the plant may be buried in the sand. The *Sagittaria* need no anchor since their buried roots hold them fast. Duckweed and water hyacinth float about on the surface of the water. The plants may be arranged in any order. We have found the following arrangement a satisfactory one.



1. Anacharis. 2. Cabomba. 3. Ludwigia.
4. Myriophyllum. 5. Sagittaria.

After the plants have been anchored, the tank is filled slowly until the surface of the water is about one inch from the top of the aquarium. This distance will prevent animals and fish from jumping out.

For a six gallon aquarium we generally use the following animals: six ramshorn snails (three red and three black); four trap door snails, and three or four goldfish, depending upon their size. In some of our aquariums we use toy fish (tropicals) and even game fish instead of goldfish. The common bullhead is an interesting game fish. Some authorities believe that for every inch of fish there should be at least a gallon of water. We have obtained better results by using a gallon and a half of water for each inch of fish.

One of the most valuable things pupils learn from an aquarium is the life balance that exists between plants and animals and how they are mutually helpful, the plants furnishing oxygen and green food for the animals and in turn receiving from them carbon dioxide and nitrogenous wastes. A perfectly balanced aquar-

Continued on Page One Hundred and Eighteen

Science Night

● By Robert Collier, Jr.
SOUTH HIGH SCHOOL, DENVER, COLORADO

The conscientious teacher is always trying to interest parents in the work their children are doing at school. "Science Night" presents an opportunity for parents to meet and to talk with teachers, and to see their children in action in the school room. An open house is a morale builder. It stimulates the lazy and the backward student; it encourages the bright pupil to do his very best.

This article is recommended for your careful consideration.

Staging a Science Night requires careful advance planning. The work is not to be undertaken lightly. There are pitfalls for the unwary. Mr. Collier has gained valuable experience by participating in public high school open house activities, He warns where the inexperienced may stumble.

Why not a Science Night for your own school?

●

From the standpoint of the school there is no public activity which will bring greater return for time and effort spent than a well conducted "Science Night" or "Open House." Every department in the modern school is able to present worth-while activities to the patrons of the school on such an occasion. Among people who normally never consider the schools and their activities, interest is aroused to such an extent that they will visit the schools for such affairs and enjoy the many interesting exhibits offered.

While the term "Science Night" is usually applied to occasions in which science serves as the "framework" upon which entertainment is planned, there is a place in such an affair for every department in the modern school, as well as for different activities carried on outside of the school by the students, whose interests differ with every individual. There is no limit to the types of educational displays that can be devised by interested teachers and pupils, assisted at times by public-spirited citizens who are willing to contribute to such an occasion. Every boy and girl entering into such an affair is given the opportunity to display some fact interesting to him, in such a manner as to bring pleasure to his classmates, parents, and community visitors.

To carry on successfully such a Science Night requires the greatest amount of whole-hearted cooperation from every teacher and student in the school. With such cooperation a well planned Science Night will attract attention from the entire community. It will bring throngs of interested patrons to the school.

Organization

Proper organization must be made a long time in advance in order that the routine of teaching in the school may not be too seriously interrupted by preparations for the evening. By collecting and carefully preserving student displays over a period of time and assigning these displays to other individuals for close study a short time before, a worth-while display may be presented with a minimum of time.

The first step is to ask every department in school to develop some project in which the class as a whole is interested. It requires, at times, considerable effort to sell the idea to some school departments, but proper salesmanship on the part of the chairman of such a meeting, together with a clearing house to prevent duplication of exhibits, will aid in preventing the overloading of some departments and the failure of others to show themselves to proper advantage. There is no department in the modern school which at some time during the year does not study material interesting to those outside of the school as well as to the pupils themselves.

The first step in preparing for a Science Night is the organization of the necessary publicity. Two departments in a school lend themselves readily to this. The art and mechanical drawing departments can make posters and direction signs for the evening, while the various English and newswriting classes can supply feature articles for city, local, and neighborhood papers. There is value to the student in preparing material for publication and pleasure in seeing his work in print. These articles, together with photographs made by city papers, will give a school and a Science Night excellent publicity. Papers are eager for material of this sort and they are always willing to give space for this type of school activity.

Traffic Control

The problem of traffic control, to care properly for the large crowds attending a Science Night, is one that requires careful advance preparation. Various uniformed groups in the modern school can lend valuable assistance in the solving of this problem, which is often overlooked. As guides, volunteer traffic officers, and information clerks, these students can render outstanding assistance. Exhibitions should be placed in rooms where there are two doors for at no time should a door be used for both entrance and exit. If possible, a proper routing of traffic should be developed so that lines of traffic will not cross or intersect. Further, a series of tickets and invitations, by which prominent people interested can be invited, is advisable. The general public can be informed that tickets should be obtained in advance, thus aiding in preventing overcrowding and consequent dissatisfaction on the part of those who might be jostled and pushed in the event of unusual crowds. Grade school children should be given a special afternoon display. They should be informed

Continued on Page One Hundred and Twenty

Visual Aids for the Science Classroom

● By Warren Taylor
CENTRAL HIGH SCHOOL, BINGHAMTON, N. Y.

This practical article is written by a teacher of science in a public high school to help other teachers of science. It will do so.

Mr. Taylor tells what good visual aids are, where and how they may be obtained, and how they are to be used. Some of the aids he suggests you can make for yourself.

Up-to-date lists of charts and displays are offered. The bibliography is a good one.

●

"A common fault found in all grades of instruction is a lack of understanding on the part of the pupils of the meaning of the facts and principles presented."[1] How many times a science teacher has tried to explain some theory or elucidate orally some fact, only to have a pupil ask "how does it work?" "I don't understand what it's all about," or "I can't quite get it through my head!' The prime importance of a teacher is to teach a pupil to *think*, using as a basis principles and facts. How, therefore, is a pupil lacking these basic knowledges to think? It is the purpose of this article, first, to point out that visualizing is important in constructing a clear mental picture, and second, to suggest some ways and means to that end.

In the classroom the initial learning step is to secure the attention of each individual. The subsequent exposition upon the topic can then progress along directed avenues, interest may be aroused, and explanation of the fact and theory may be made. Through significant experiences which are of common occurrence, or through some unusual experience which normally occurs in a science class, attention may be at once obtained. It has been estimated that two-fifths of all experiences are received through the optic nerve. Therefore it is the optic nerve which must be stimulated to a large extent. This may be accomplished by reference to a diagram, chart, model, or other simple illustration. At times it is worth while to exhibit a bit of startling action. However, recreative stimuli should be avoided. In the explanation of fact, and particularly theory, reference to something tangible and within the experience of the learner is made much more impressive when it is of a visual nature. A receptive attitude, acquired through attention, means better assimilation and retention; attention requires the use of some visual experience.

Teaching by illustrative objects is not new to the profession, for as far back as 1860 the Oswego (New York) Normal School was propounding its merits and practices, taken from the advocator of object teaching, Pestalozzi. Today, there are numerous means presented to teachers of science who have only to use a little initiative and cleverness to obtain them. Recent literature has been full of the merits of moving pictures, glass and film slides, and the stereoscope as a means of bringing vividly before the pupil the more important topics. From the result of tests with control and experimental groups using these devices, it is generally conceded that the learning situation is enhanced. However, few schools can afford the outlay necessary. Other portions of the visual program are more difficult to measure and evaluate in terms of results. It is true that the explanation of certain difficult points is made clear in individual cases by models, exhibits, and at times, properly constructed charts and diagrams.

Many school budgets are not yet fully on the road to recovery. This necessarily means a curtailment to some degree in the number and amount of purchases possible in science. Supplies must be renewed; therefore it is usually in equipment that schools lack what they should like to possess. The question now is: What are some sources of materials which require little, if any, money outlay?

Handwork

There are three groups of visual aids which will require of the science teacher a comparatively small pecuniary outlay. A first group may be any kind of handwork. Aside from blackboard illustrations, there are drawings, diagrams on cardboard or drawing paper, articles cut from cardboard (showing the operation of some mechanism) and any object produced from wood or metal. These may be used particularly in physics and chemistry, but the inventive and artistic teacher may use these aids to great advantage in biology.

In chemistry, the author has made use of a homemade device to illustrate the Bohr system of the electron theory. On cardboard circles ranging from three to ten inches in diameter, are drawn the atomic nucleus and the concentric rings, the outermost of which provides space for large, black-headed upholstery tacks to represent the electrons. According to their atomic structure, some atoms will have one, two, three, and so on up to eight electrons in the outside circle (for the sake of simplicity only atoms of atomic number 20 or less are considered), and may therefore loan one, two, three, four, or borrow as many electrons. As well as being a means of showing the nature of the atom and some of its physical and chemical characteristics, it is also an appropriate means of introducing the subject of valence, using only the term "combining power."

Another difficulty encountered in chemistry is the conception of molar volume, particularly when working

[1] Colvin, S. S., "An Introduction to High School Teaching." The Macmillan Company, New York. 1919. p. 244.

certain types of problems. A cube, either of wood or ordinary gauge galvanized iron, approximately 11⅛ inches on a side, will have a capacity of 22.4 liters. Whether wood or metal, this cube may be decorated according to the teacher's taste.

In chemistry, a block of wood treated with sulphuric acid is enough to show the dehydrating effect of the acid.

In physics there may likewise occur a use for home-made aids. To show the force of atmospheric pressure, a syrup can or varnish can filled with steam from water inside the can, stoppered and allowed to cool, invariably produces amazing results. A round bottom flask, partly filled with lead shot and held in place by cotton, will produce the desired effect in illustrating equilibrium. When the closed end of a test tube is drawn out quite fine, the fine portion bent to form a U and the whole set into a wooden block by means of sealing wax, there appears a means of demonstrating capillarity.

A four-inch piece of one-inch glass tubing may be stoppered by a cork securely fastened with adhesive or friction tape. Two wires previously placed through the cork may act as a spark plug when connected to an old Ford spark coil and batteries. When this tubing is filled with the correct proportion of hydrogen and stoppered lightly at the free end, the resulting explosion, resembling a toy cannon, will illustrate the force developed in an internal combustion engine.

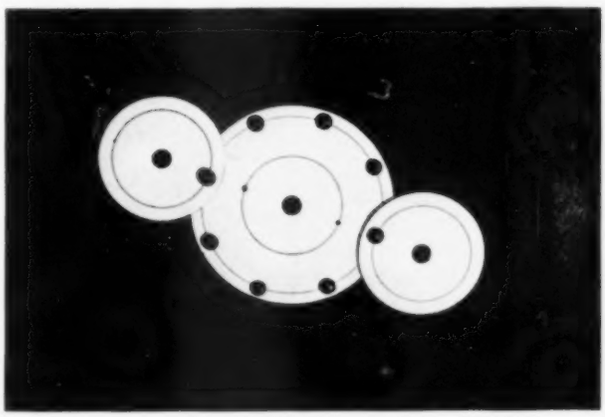


FIGURE 1

CARDBOARD CIRCLES TO REPRESENT WATER (HOH) ACCORDING TO THE BOHR ARRANGEMENT.

A lens may be produced from two thin watch glasses, water, and sealing wax, or ice may be so melted and shaped to function as a lens.

Various bits of electrical apparatus may be made from al sorts of odds and ends, the home-made apparatus often being as useful for demonstration and explanation as purchased articles.

Biology teachers may well make use of home-made aquariums, terrariums, plaster-of-paris casts of animal foot prints, leaf prints (spatter prints), and smoke prints (the last few as a means of identifying the respective objects).

Advertising Material

A second group of visual aids is concerned with advertising. Some advertising may not be in the desired form; it may not deal with the phase of subject matter that is desired; or it may be of such size that it cannot

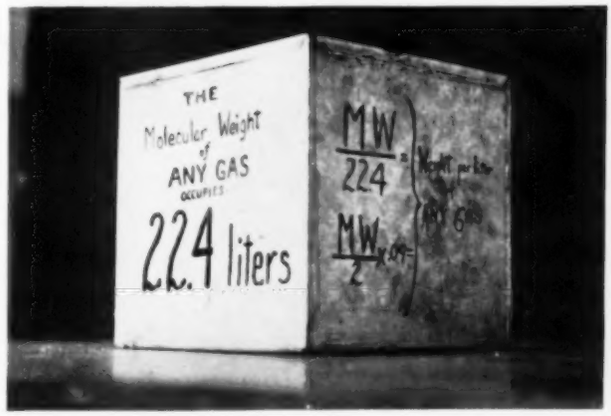


FIGURE 2

A GALVANIZED IRON CUBE, MADE IN SIZE TO EQUAL THE MOLAR VOLUME OF A GAS.

be used in the classroom. There are four forms of advertising materials which are valuable as visual aids, namely, moving pictures—sometimes with sound; glass or film slides; models and exhibits; and charts and diagrams. The first and second forms require a projector. If the proper kind of projector is available, moving pictures and slides will solve the problem of visual aids in certain topics. Motion pictures and slides have many advantages but they likewise have the possible disadvantage that the attention of the pupil is often attracted to the visual aid itself as an end, instead of being focused on the point to be illustrated *by* that aid. This is sometimes true with exhibits and models and charts. At the end of this article is given a brief list suggesting possibilities from advertising.

Other Sources

One of the most valuable groups of aids is that which includes the offerings of visual societies and like institutions, state and federal governments. The United States Bureau of Mines in Pittsburgh, the individual state libraries, the Society for Visual Education in Chicago—connected with the University of Chicago—and others[2] will supply lists of materials which they are

Continued on Page One Hundred and Fifteen

[2]A list is available from Woodring and Others, "Enriched Teaching of Science in the High School," Columbia University. (Teachers College) publication, 1928. In some respects now out of date. See list at the end of this article.

Aims and Objectives of the High School Course in Physics

● **By Rev. John H. Crawford, O.S.A., A.M.,** *(Villanova College)*
DEPARTMENT OF PHYSICS, VILLANOVA COLLEGE

Do high school courses in science greatly benefit the college freshman? Is preparation for college one of the major aims of high school physics? Can certain desirable educational objectives be reached through a study of physics more readily or more satisfactorily than by any other study in the high school curriculum? What special goals should the teacher keep in mind? Are these attainable?

You will be interested in Father Crawford's opinions.

This article is based on a paper read and discussed at an Augustinian Educational Conference recently held in Washington, D. C.

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In this paper it is not my intention to dwell on the aims and objectives of education in general, nor on those of the high school course or the science course, but only on the particular goal which the teacher of physics in the high school should make it his ambition to reach, at least in some measure. Of course, I do not mean to imply that we can divorce the aims of the course in physics from the aims of the other science courses, or non-science courses, but if we are able to justify the existence of a course in physics in the high school curriculum, then it should be possible for us to point out some specific aims which this course is designed primarily to attain, and which, at the same time are not attained, at least in a marked degree, by any other course in the curriculum.

Preparation for College

In view of the fact that only sixteen per cent of high school pupils continue their education after they leave the high school, I believe that it is quite safe to say that preparation for college is definitely not one of the aims of the high school course in physics. This statement is made as a general one which allows of many exceptions.

In the specific case of the secondary schools conducted by the Augustinian Fathers in this country, I have figures for only three of the preparatory schools and for the one high school—St. Thomas High School, Rockford, Illinois. Comparison of the number of graduates with the number of college entrants for the four years would seem to indicate that our preparatory schools send more than fifty percent of their graduates to college while the one high school has sent only nineteen percent in the last two years. (There were no records for '32 and '33.) Hence, we might be inclined to think that we should distinguish between the high school and the preparatory school when we state the aims of the various courses in the curriculum.

However true that may be for non-science courses, it seems to be the opinion of those who have investigated the matter that high school courses in science and particularly in physics are of no special benefit to the college freshman or sophomore. As a result of a survey by Foley, conducted in eight Indiana colleges, we find that for the same college course in physics the average grade of those who had had high school physics was only 4.1 per cent higher than that of those who had had no high school physics. From my own personal experience gained during nine years of teaching freshman physics at Villanova, I have gathered the general impression that high school courses in physics have not been of any particular benefit. I must admit that I have never made a special study of this point, but my impression is in agreement with the findings of those who have gone into this question seriously.

We are justified, then, I believe, in reaching this negative conclusion at the outset, *viz.*, the high school course in physics is not intended to be a preparation for a college course in the same subject. While this is a negative conclusion, it is nevertheless an important one because the implication contained in it has much to do with the matter presented in the course and the manner of its presentation.

Major Goals of Science

The major goals to be attained by any science course are listed by Downing as the following: (a) knowledge; (b) skill in scientific thinking; (c) establishment of emotionalized standards. It is true that these are the major goals of any science course and in accordance with our preliminary statement it is not our intention to discuss these as such. However, these goals are proper to physics in a special way and it is our problem to indicate in what manner the high school physics course can be made to lead to these goals. Let us consider them in the reverse order to that in which we have named them.

Establishment of Emotionalized Standards

We take up first the establishment of emotionalized standards. Among these may be listed in the very first place a feeling of admiration and of adoration for the Creator of the universe Who has established, with such precision and accuracy and with providence for the welfare of the works of His hands, the fundamental laws of nature that are the basis of the course in physics. There can be no doubt that the opportunities which are in the hands of the physics teacher to emphasize the omnipotence and the providence of God are

innumerable. While it would be impractical for us to attempt to point out the enormous number of facts and principles which might be used for this purpose, let me cite just a single example. In discussing the fact that the maximum density of water occurs at four degrees Centigrade, and not at zero as we might expect, the physics teacher can easily bring to the attention of the students that if it were otherwise, lakes and ponds would freeze from the bottom up instead of from the top down, and as a result the fish in the ponds and lakes would all perish the first time such freezing took place. This fact can be mentioned as an example of the manner in which the laws of nature have been established by the Creator for the protection of His creatures.

A second emotionalized standard that can be readily developed by the physics teacher is that of admiration for the heroism and self-sacrifice of many scientists. The history of physics is a most fascinating subject, and in its study we discover the names of such men as Galileo, Newton, Avogadro, Kepler, Huygens, Maxwell, Faraday, Becquerel, Thompson, Röntgen, Planck, Einstein, Michelson, Compton, Millikan, and many others who have devoted lifetimes to patient research, sometimes under the most trying circumstances, working only for the welfare of mankind and the extension of human knowledge, rather than for their own selfish ends.

The lives of many of these physicists are shining examples of the virtue of patience and the reward that comes from painstaking effort. For example, we might quote the remarkable work of Millikan in the determination of the charge of the electron. He began this work in 1906, and as a result of the most elaborate precautions for the elimination of error and for the detection of those errors that were impossible of elimination, obtained, in 1916, a result that is looked upon by all scientists as one of the most accurate determinations of a physical quantity that has ever been made. Examples such as this one, which may be brought home to the student at various points in the physics course, will serve to develop in him a respect and admiration for the work of these men and at the same time produce the conviction that the advice of experts such as these is worthy of great credence. And is not the need of advice and the necessity of listening to those who are qualified to speak, one of the most important lessons that youth needs to learn?

Another emotional standard that is very desirable in the youth of our day is respect for law. Physics, with its laws of nature that are seen to be so regular and exact and from which there is no exception, provides an excellent method of instilling respect for law and authority into the minds of the young. It is comparatively easy for the physics teacher to draw the analogy between physical and moral laws. We can point out that the consequences of our failure to observe the moral law will follow just as surely as do the effects, for example, of gravitation. But perhaps we delay too long on this particular goal of the physics course which is after all, a secondary one. Let us proceed to the second goal; skill in scientific thinking.

Scientific Thinking

It is scarcely necessary to point out the utility of scientific thinking for the solution of any problem, be it scientific or not. Of course, by scientific thinking we mean nothing more than straight, logical, correct thinking along the lines that are peculiar to science. Perhaps it might be well to recall briefly how the scientific method proceeds and to point out the value of the method in the problems that arise in the daily lives of all of us. The teacher of science and especially of physics should not only make use of this method for the solution of his own personal problems and for the solution of problems in the class-room; but he should point out to the pupil the various steps he is taking, so that the pupil may obtain a clear insight into the method and thus acquire facility for himself. It is a pedagogical principle that we learn best by doing, and so the pupil should be trained in the scientific method by actually applying it to the solution of problems in the physics course.

The first step in the process of thinking scientifically is to gather data. This, of course, follows only after the existence of a problem has been established, and that problem has been clearly defined. He would be a poor scientist, indeed, who set out to gather data without a specific problem in mind. The gathering of data leading to a false conclusion even under the most logical reasoning is found in the teaching of Aristotle regarding the rate at which bodies fall under the influence of gravity. His inaccurate observations led him to conclude that the heavier bodies fall more rapidly than the lighter ones; hence, that the rate of fall of a body is a property of matter. If his observations, and therefore, his data had been more accurate he would have seen that the rate of fall is independent of the amount of matter a body contains. The data gathered for the solution of a problem ought to be extensive and gathered under a variety of conditions.

After the data has been collected, the next step is to analyze and synthesize what has been found. This is, perhaps, the most important and at the same

Steps in the Development of Shelter

A high school science project prepared by Earl Stochr, St. Joseph's High School, Mt. Oliver, Pittsburgh.

time the most difficult part of the scientific method. It is necessary that we be able to select the essential elements contained in the data that has been gathered, and to eliminate all that is not essential. It is important, too, to regard unlikenesses as well as likenesses, in order to analyze our findings properly.

After we have made an analysis of the results obtained, it then becomes necessary to derive some conclusion in the form of a hypothesis or theory. Usually, the formulation of a theory comes about only after one or more hypotheses have been tried in a large number of cases. One of the tests of our hypothesis or theory, as the case may be, is the ability to predict results of further experiment. An example of the failure of a hypothesis in the prediction of results is seen in the early eighteenth century notion as to the nature of heat. At that time the caloric hypothesis was offered to explain various heat phenomena. Count Rumford reasoned that if heat is a material substance which passes from one body to another, then a body should increase in weight when it becomes heated. So he weighed a cannon that was to be bored, and the boring tool; after the boring was completed both were weighed again, and although a great amount of heat had been generated in the procedure, neither the cannon nor the boring tool had increased in weight. This fact was interpreted by Count Rumford to indicate that the caloric hypothesis was not true. On the other hand, there is the very striking and important example of Maxwell's Electromagnetic Theory of Light. Through the careful and accurate assembling and coordinating of data, Maxwell, after years of patient examination and analysis, formulated the now famous equations which bear his name. From a further consideration of these equations he concluded and predicted that it should be possible to produce electrical waves of the same nature as those of light. Hertz undertook the task of verifying this conclusion, and as a result we have today—The National Broadcasting Company.

Another very important factor in the scientific method is unprejudiced judgment. We must be willing to give assent to the facts brought before us regardless of the effect that the conclusions drawn from them may have upon us personally.

A very striking example of the effect of prejudice is found in the case of Galileo. The facts that he presented as a result of his experiments with falling bodies dropped from the Leaning Tower of Pisa showed without doubt that all bodies fall with the same speed in spite of differences in weight. But this conclusion was contrary to that of Aristotle which we have already mentioned; and hence, it was rejected because of this great prejudice in favor of Aristotle; and more than that, Galileo was expelled from the University of Pisa for daring to teach a doctrine opposed to that of Aristotle. The great Sir Isaac Newton was guilty of this same fault. He observed that water waves bend around the corners of obstacles placed in their path. This bending was not seen in the case of light, so Newton, because of prejudice, refused to accept the wave theory of light. As a result of his refusal, the prejudice of others in his favor retarded the acceptance of this theory for almost one hundred years.

Thus far we have dwelt with the inductive process in our discussion of scientific thinking. While this is most important for the formulation of hypotheses and laws, yet the other side of the method, deduction, is probably of more importance to the everyday problems that arise. Deduction is more or less the direct opposite of induction. By induction we go from specific cases to general principles; by deduction we pass from the general to the particular. Here the important point is to select the proper principles from those that we know, and to apply them to the problem at hand.

Knowledge

Perhaps this part of the scientific method can best be considered after we have discussed the third main goal of the high school physics course, which we have called knowledge. To quote Downing:

> "Two methods of instruction are conceivable in preparing pupils to meet the problematical situations involving scientific knowledge that will arise in their lives: (1) One may list all such problems that occur in the community and make pupils skillful in meeting each, teaching them how to do each specific thing. (2) Or one may give them an understanding of the principles of science that are most often needed to solve such problems and then may drill them in solving problems under such principles, leaving them to think through such other problems as shall occur in their later lives."

If the physics course is to be justified in the high school curriculum then we have a right to expect that it shall be of some benefit to the student after he has left the classroom. No one can doubt that the number of problems that arise in the daily lives of most people whose solution depends directly on the principles of physics, is very great. It is readily seen, then, that the first method mentioned by Downing is of no practical value. It would be impossible for the physics teacher to begin to enumerate and solve these problems. For example, one of the most common mechanisms met with in our daily lives is the automobile. In order to take care of this particular piece of machinery it is necessary to know how to do 399 different things. On the other hand, there are only 12 principles underlying these 399 operations. And the same sort of statement can be made with regard to other things. The operations are many, but the principles are few.

The logical and reasonable thing to do, then, in the high school physics course is to teach these fundamental principles and the way in which they may be applied to problems, and let the pupil learn for himself the numerous applications that will occur later. The second half of this statement is just as important as the first. It is not sufficient to instruct the student in the principles so that he can recite them from memory without fail. It is also necessary that he be drilled in the solution of many typical problems, so that he may see for himself how the principles may be applied.

Continued on Page One Hundred and Fourteen

Roger Bacon, *Scientist*

Father of Experimental Chemistry

● **By Dorothy Favini**

SCIENCE CLUB, MARYWOOD COLLEGE, SCRANTON, PA.

From a student member of the Roger Bacon Science Club of Marywood College comes this interesting article on an important Catholic scientist of the thirteenth century.

Miss Favini sees Roger Bacon as "A truly great man—a scientist, philosopher, and scholar that made him a worldly man; a humble, believing, and devoted Franciscan friar that made him a religious man."

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Roger Bacon was born into an England which was infused with scholasticism, a movement that made Aristotle infallible and the theories of the Greek physician of the second century, Galen, absolute. The former had solved all conceivable problems having to do with metaphysics and natural history. The latter had learned and made known everything about the human body and the use of medicines. There was then, no need for a Roger Bacon, a man who was later to be known as *doctor admirabilis*, and who was to have the effrontery to refuse to accept all scientific things on blind faith alone.

ROGER BACON (1214-1294)

Roger was born at Ilchester, Somersetshire, in England about 1214, under the rule of Henry III. At school age, his family, although they had lost a great deal of property and suffered serious financial setbacks because of loyalty to their monarch in his struggle with the English barons, were, nevertheless, able to send the boy to Oxford and later to Paris where he received his degree of doctor of theology. While at the University in Paris, he became interested in the Arabic writers, and it is believed by some and disputed by others, that it was from them that he derived his formula for the making of gun powder. Certain it is, however, that he was the first to introduce the explosive into Europe.

Though the exact date at which he joined the Franciscan Order is not known, it has been proven that in 1250 he began a series of lectures at Oxford as a friar of the Franciscan Order. Shortly, his health gave way and for ten years he had "owing to many infirmities to withdraw from taking any public part in university affairs."

During this period of retirement, he devoted himself to investigation and experimentation in the field of physics, in its branch of optics. It was, perhaps, through these pursuits that he was able to predict the forthcoming microscope and devices by which "more distant objects can be made to appear near at hand or far away." He knew the affairs current throughout the country and was particularly attracted to a study of the important discoveries of his time, both geographical and mechanical.

Bacon's real opportunity, however, did not come until Guy de Foulques had been elected to the Papal throne as Clement IV. The new Pope encouraged the friar and requested him to send him his works. Bacon produced his famous "Opus Majus" consisting of the following essentials —"a criticism of the spirit in which scientific studies were then pursued; an attempt at a classification of the sciences; and finally, an exposition of a new scientific method." It was in this work that he gave experimentation its rightful place as a necessary fundamental for the pursuit of discovery. This work was followed shortly after by the "Opus Minus" and "Opus Tertium." At their completion they were sent to the Pope, but, unfortunately, Clement IV died before they could be of any real value to him.

After the death of Clement IV, Bacon had many difficulties to surmount, for at this time there was incessant quarreling between the two Orders of Dominicans and Franciscans, and the Minister General of the Franciscan Order, Jerome of Ascoli, was prevailed upon to condemn Bacon and his doctrines. It has been asserted that Bacon was imprisoned although this has not been successfully proven. His remaining years were spent in writing and further experimentation. He died at Oxford about July 11, 1294.

Even today, Roger Bacon stands out as a most remarkable man. He was a master of all the scholarly studies, including mathematics, philosophy, physics, languages, astronomy, geography, and chemistry. He

Continued on Page One Hundred and Twenty-four

Industrial Abrasives

● By Duane E. Webster
CHEMIST, WORCESTER, MASS.

To a considerable extent the works of man have always depended upon his skill in abrading.

In the modern world especially, the grinding industry has made itself an indispensable element in commercial progress. It was not until recent years, however, that manufactured abrasives, products of the electric furnace, were substituted for the natural rocks that have been used since the earliest times.

This article summarizes briefly the progress that has been made in an industry the importance of which is often not appreciated.

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From the relics of prehistoric races, and from the fragmentary records of primitive peoples we learn that the shaping of metallic or other relatively hard objects by grinding or abrading has been practiced from the earliest times.

As might be expected, the methods employed at first were simple, the workers inexpert, and the resulting objects far from perfect. The only grinding implements used were those ready at hand, the commonly occurring rocks that have abrading qualities, and it is surprising to learn that until comparatively recent times natural rocks were still the only tools available for such work. In late years, however, developments within the grinding industry have been rapid. Advances were made necessary by the insistent demands of the commercial world for increased production and better products. Greater refinement and flexibility in the grinding machine must be obtained. Research was begun. Old abrasive materials and grinding methods were subjected to scientific study with the result that new and better abrasives were devised, and old and imperfect methods were supplanted by modern ones that produce amazingly accurate results.

There is scarcely an industry that does not owe something to the recent advances in grinding. Grinding is one of the big factors in the low cost and mass production of engines of all kinds, armament, printing presses, wood-working machinery, microscopes and telescopes, typewriters and linotype machines. It is concerned directly or indirectly in the making of most of the manufactured objects with which we come in daily contact. One of the greatest contributions of the grinding industry to the manufacturing world has been the commercial development of extreme accuracy in the grinding of cylindrical parts. Modern grinding machines produce continuous parts that are flawlessly precise and true. Had it not been for the grinding machine the automobile could not have reached its present state of perfection. Each of the close fitting parts of an automobile must be ground. The magnitude of the grinding departments of the large automobile manufacturing plants, where batteries of grinding machines of almost every type are employed, is evidence that grinding is an important factor in obtaining speedy production, fine quality, and moderate cost.

Agriculture also has profited. Reaping and mowing machines, threshers, the great tractors that perform the hard labor of the farm, as well as practically every other tool of the farmer, all are produced by the aid of grinding wheels and machines. Grinding is a factor in the increased use of processed farm products. It is involved in the production of breakfast foods such as corn flakes and shredded wheat. The smooth and velvety flours and the fine grades of chocolate with which we are so familiar are dependent for their fineness upon the character of the surface of the rolls used in their production. The quality of the roll depends upon how accurately it has been ground.

As research in the grinding field was continued, it became apparent that any marked improvement in grinding would require not only better grinding machinery but better abrasives as well. The answer to the demand was found in the products of the electric furnace. How important these artificially produced abrasives have now become is seen from the fact that more than 100,000 tons of them have been produced in a single year.

Up to fifty years ago the only tools available for abrading were the grindstone and whetstone. These were fashioned from natural rock that had been formed by the deposition under water of coarse and fine grains of quartz sand in beds of varying thickness. As the water gradually withdrew from these deposits, the grains of sand became cemented together to produce "sand-stone" of different qualities and strengths. From such rocks the first grindstones were hewn and made ready for use. The cutting agent of such stone is the sharp and hard grains of the sand it contains, and no material can be abraded or ground rapidly with sandstone if it is of a hardness greater than that of quartz. There is thus a very definite limit to what can be accomplished by the use of a grindstone.

Even before a systematic search for better abrasives was begun it was well known that there are certain natural minerals that are harder than quartz. Corundum and emery are fairly common minerals of this type. They occur in amounts large enough for commercial production at moderate cost. It happens, however, that they do not occur in nature conveniently bonded together like the hard crystals are found in sandstone. Some way of binding them must be discovered.

Among the early experimenters in this field were the men responsible for the later organization of the company now known as the Norton Company, of Worcester, Mass. These workers had a convenient and valuable knowledge of the art of the potter which they drew

upon to good advantage. They decided to use pottery mixtures for binding the abrasive grains. Their choice was a good one. They were able to make a mass that held together with such firmness that from it grinding stones could be fashioned.

The new manufactured stones were a great advance over the natural stones. Their cutting quality was better because of the harder and sharper materials they contained. But a difficulty arose when there came a demand for the large-scale production of the wheels. Exact duplication was difficult or almost impossible because individual natural deposits of emery and corundum vary so much in their uniformity. The fact that the product obtained in one locality may be quite different from that obtained elsewhere, presented an additional difficulty. It was evident that a consistent uniformity of these artificial stones, manufactured from natural minerals, could not be attained.

The search for new grinding materials was continued. This time a definite, well conceived and well directed search, not a blind groping in the dark. The demands of industry were becoming more persistent. The demands must be met. Wheels must be produced that would be at least as efficient as those made of corundum and emery, and at the same time sufficiently uniform that they were capable of reproduction.

It was during this stage of the development of the grinding industry that the products of the electric furnace began to show commercial possibilities. Research was directed in this new direction, and from the electric furnace now come the modern artificial abrasives that are the foundation of the great grinding wheel and grinding machine industry of today.

The first of the artificial abrasives was crystalline silicon carbide, SiC, first made in 1893 by Edward G. Acheson. The few ounces produced by his little electric furnace, located in Western Pennsylvania, consisted of a hard mass of brilliant, shining crystals. The exact composition of this new material, later to be called carborundum, was at first not known. When the material was found to be high in the scale of hardness (between 9 and 10) practical uses were sought for it. It turned out to be an excellent abrasive.

At first it was used to polish precious stones. Its cost was in the same range as that of the materials on which it was used. Later, commercial production was begun, and the Carborundum Company was formed to arrange its development, large-scale production, and sale. The new company experienced the usual difficulties encountered by pioneers in any new commercial venture. These were overcome in time, and, eventually, a manufacturing plant was built at Niagara Falls, a location which made available comparatively cheap hydro-electric power. Here in great electric furnaces of the resistance type silica sand and metallurgical coke are heated together. The carbon of the coke reduces the silicon dioxide and combines with the silicon so set free to form the exceedingly hard crystals of silicon carbide. These are pulverized, mixed with binding materials, and molded into grinding wheels.

Crystalline silicon carbide is sold under trade names such as crystolon and carbolon as well as carborundum. Abrasives of this type are most effective in grinding materials of low tensile strength; consequently most grinding wheels still had to be made of emery and corundum. A satisfactory substitute for these was still to be discovered. It was found. In the laboratories of a small electro-chemical company at Ampere, New Jersey, a reproduction of a natural aluminous abrasive was made from the mineral bauxite by the use of the electric furnace.

The first experiments, which were performed in 1897, consisted in the fusion of natural bauxite, the chief constituent of which is aluminum oxide. The results obtained were important enough to arouse a great deal of interest. Several hundred tons of the new abrasive were produced so that extensive tests could be conducted. The tests were satisfactory, and the Norton Company took over the manufacture of the new crystalline aluminum oxide. They called the product alundum. A plant for its production was constructed at Niagara Falls.

Bauxite is a clay-like material which is found in many parts of the world. It is composed largely of hydrated aluminum oxide which is associated with smaller quantities of the oxides of silicon, iron, titanium, and other elements. Before it goes to the electric furnace the bauxite is calcined in order to remove the combined water that it contains. The aluminum oxide content of the ore is in this way increased. A modified arc type of electric furnace is used. During the operation there is a reduction of the accompanying metallic oxides. Not only the chemical composition but also the manner of crystallization have an important bearing on the abrasive qualities of the product. Consequently both are carefully controlled in order to prepare products that will be suitable for the special uses to which they are to be put.

Aluminum oxide abrasives of the alundum type are especially valuable because they are efficient in grinding materials of high tensile strength. They thus have a wide field of application, for the amount of grinding done on strong materials is much greater than that done on materials of lesser strength. Artificial aluminous abrasives are sold under the trade names aloxite and lionite as well as alundum.

Research on abrasive materials and grinding methods is, of course, being carried on continually. Further improvements within the industry may confidently be expected.

◆

Airplane Engine and Propeller

●

A high school science project constructed by John Askin, St. Francis de Sales High School, Pittsburgh.

Heavy Hydrogen and Heavy Water

● **By Roland Schaffert, Ph.D.**, *(University of Cincinnati)*
RESEARCH PHYSICIST, NEW YORK CITY

Can any water be worth a million dollars a gram? Is there more than one kind of heavy water? What is it? Will it prolong life, or kill? What effect does it have on chemical reactions? May it be useful in scientific research? Will it be used in medicine?

Here is a brief discussion of some of the more recent facts and findings concerning deuterium oxide, and some suggestions as to its possible influence on future scientific developments.

●

The year 1932 will long be remembered in science as one of discovery, for it was in this year that scientists first established the existence of three fundamental entities, the neutron, the positron, and the first isotope of hydrogen. The neutron was discovered by Professor Chadwick of England, the positron by Dr. Anderson of the California Institute of Technology, and the hydrogen isotope by Professor Urey of Columbia University. The new isotope, which has an atomic weight of 2.0136, is now called *deuterium*, while ordinary hydrogen of atomic weight 1.008 has been given the name *protium*. In this paper we shall use these names to distinguish the two forms of hydrogen.

Dr. Urey was first led to suspect the existence of the hydrogen isotope by his study of the regularities in the structure of the nuclei of known atoms. About this time Professor Allison, working with his magneto-optic method of analysis, observed two minima which he interpreted as being due to two isotopes of hydrogen. Somewhat later R. T. Birge and D. H. Menzel, from a study of the discrepancy of the chemical atomic weight and mass spectograph value for the atomic mass of hydrogen, predicted that a hydrogen isotope would be present in ordinary hydrogen to the extent of one part in 4500.

The deuterium obtained in Dr. Urey's first experiments was prepared by the fractional distillation of liquid hydrogen near the melting point. He and his research assistant, Dr. Murphy, proved the existence of the isotope when they found that its spectrum corresponded to that of a hydrogen atom of mass 2. The experiment was not so simple as might be expected, however, since their first sample contained only a small fraction of one per cent of deuterium. Urey's discovery was later confirmed by Dr. Bleakney of Princeton University by the use of the mass spectograph. It was not until he was able to obtain deuterium in greater concentrations that Dr. Urey convinced the scientific world that the isotope actually existed. These greater concentrations were made possible by the discovery by Dr. Washburn of an electrolytic method of separation. Since Dr. Washburn's discovery extensive research on the isotope and its properties has been in progress. In Dr. Washburn's process it is not heavy hydrogen that is separated, but *heavy water*, a compound containing deuterium. Heavy water is called deuterium oxide, D_2O, to distinguish it from ordinary "light" water, H_2O.

Deuterium oxide is a colorless liquid that is quite like ordinary water in appearance. It is very hygroscopic. This is something new, to speak of a water as being hygroscopic. Nevertheless, nearly every molecule of water that comes in contact with liquid D_2O will stick and be absorbed. An open container filled with heavy water becomes diluted with water rapidly if water vapor is present. Heavy water differs from "light" water in many of its properties. A table showing some of the differences between the two is given later in this paper.

Heavy Water in Nature

Deuterium oxide, "heavy water," is present in ordinary surface water, such as tap water, to the extent of one part in 5,000. This is not true, however, for all natural waters. Small variations in this concentration have been reported from various parts of the world. Investigators in England have found tap water that contains D_2O in the ratio of 1 to 10,000. Water obtained from oil wells at a depth of 5,000 feet has been found to have about the same concentration as surface water, while that removed from natural gas has been shown to have a slightly greater concentration. Water taken from a lake in Russia at a depth of 6,500 feet had a somewhat greater density than the surface water. Evaporation from brine apparently concentrates deuterium oxide. Sea water is heavier by two parts per million than fresh water. The difference may be due to natural distillation. Water from the Dead Sea is 2.1 parts per million heavier than ordinary water; that from Great Salt Lake is 2.7 parts per million heavier. Water that is obtained from rasorite (native borax tetrahydrate), is 6.9 parts per million heavier. Water of crystallization generally contains somewhat greater concentrations of deuterium oxide.

It was thought that heavy water might be one of the factors in the healing effect of natural mineral waters. With this idea in mind some 20 samples of mineral waters were analyzed, but in no case was an abnormal amount of heavy water found. Water obtained by burning carbohydrates contains increased concentrations of heavy water. There is a slight physiological concentration of D_2O in plants, willow sap containing it to the extent of 2.9 parts per million more than ordinary water. Milk and orange juice have a normal D_2O content.

The greater weight of the molecule of D_2O and its consequent slower evaporation should cause a relative

excess of heavy water in the last remnants of disappearing lakes that have no outlet, in solutions inclosed in salt deposits, and in the steam emitted by volcanoes or geysers that have been active for a long time.

Benzene, kerosene, and honey apparently contain a slight excess of deuterium.

It must be appreciated that the analysis of samples to an accuracy of parts per million requires great skill and most careful measurement. For this reason the values given above should not be taken as final since many workers fail to give sufficient details of their experimental procedures.

The discovery of deuterium oxide and of deuterium will undoubtedly have far-reaching effects on the future development of biology, medicine, chemistry, physics, and the other sciences. Advances have already been made. A few of the more interesting observations that have been reported in connection with heavy water are mentioned here.

In the Biological Field

The effect of heavy water on biological processes is very interesting and highly important, since all living things live, essentially, in a water solution. In 1933 investigators at Princeton University found that heavy water of 92% concentration killed tadpoles, flatworms, a species of fish and some protazoa. Later, Lewis reported that while tobacco seeds germinated slowly in 50% D_2O, in a 100% solution they germinated not at all. Marine bacteria and molds did not grow in heavy water. A ten-gram mouse which drank 0.66 grams of D_2O within three hours showed temporary signs of intoxication. Lewis concluded that "the effect of D_2O reduces the rate of all physico-chemical processes when D replaces H."

Interesting as these results may be, even more remarkable are the results obtained with dilute solutions. Investigators at Yale University have found that dilute solutions of heavy water (0.06% to 0.5%) *stimulate the growth, development, and activity of primitive cells and increase their life span.* From other sources come reports that dilute solutions increase enzyme activity and promote photosynthesis and bacterial growth. These results indicate the probability that optimum conditions for living organisms require a definite concentration of D_2O. A few of the biological effects of heavy water are noted.

Dilute Solutions

Dilute solutions of heavy water (0.06% to 0.5%) increase the life span of simple cells.

Cultures of *spirogyra* exhibit much less abscission or cell disjunction and greater longevity in 0.06% D_2O. Felts of *Aspergillas* grown in 0.4% heavy water have an average weight of some 16 times that of those grown in ordinary water. Experiments on *Es. coli* and *Ps. aeruginosa*, bacteria present in the human body, show that water of less than 0.54% favors bacterial growth.

Concentrated Solutions

Injection of 1 cc. of 99% D_2O in the white mouse depressed the metabolism to approximately half the normal level in the succeeding 9 to 12 hours. High concentrations of heavy water kill the spermatazoa of the frog and inhibit the development of the egg of *Arabica punctulata*. Pea seeds do not germinate in solutions of heavy water of a concentration greater than 50%, but wheat germinates equally well in heavy and light water. Increased concentrations of D_2O *favor the growth* of tuberculosis bacilli and *do not inhibit the growth* of either *Staphylococcus albus* or typhoid bacteria.

The pulsation frequency of the excised heart of the frog can be slowed down in 20% heavy water. The enzyme catalase destroys hydrogen peroxide. It does so at only half the normal rate in 85% heavy water. The oxygen consumption of yeast in 98% D_2O is decreased by one-half over than shown in ordinary water.

Effects on the Human Body

Because of the unfavorable effect of high concentrations of heavy water on various organisms, it has been suggested that one of the possible causes of old age may be an accumulation of D_2O within the body. The analysis of body excretions after the drinking of heavy water shows, however, that no accumulation takes place. Water separated from the brains and livers of old men, from the flesh of old oxen, and from other tissues and organs showed normal D_2O content. Such a view is also contradicted by certain experiments with dilute solutions of heavy water, which make it much more likely that a slight increase in D_2O content of the body may prolong life. Perhaps a dilute solution of heavy water is to be found in the long sought and never discovered "fountain of youth."

In Medicine

But few investigations as to the therapeutic effect of heavy water have yet been reported. A few experiments on cancer (rat and mouse sarcoma) gave no appreciable effects. Heavy water, however, does stimulate the growth of tumor tissue. It is entirely possible that, in the future, heavy water in various concentrations may form an essential part of certain medicines.

In Chemistry

Since heavy water, D_2O, is only one of a large number of deuterium compounds, it becomes necessary to make a distinction in terminology. Those compounds of hydrogen in which H is replaced by D are called *deutero* compounds to distinguish them from the *proto* compounds which contain H. For example: DCl is deuterium chloride; $DC_2D_3O_2$, is deutero-acetic acid. For each of the several hundred thousand compounds of hydrogen there can be a corresponding deutero compound. The number of possible compounds is further increased by the fact that both H and D can be present in the same compound. The number of combinations is so great that it is beyond the power of the imagination. With benzene, C_6H_6, for example, we may have C_6D_6, C_6HD_5, $C_6H_2D_4$, $C_6H_3D_3$, $C_6H_4D_2$ and C_6H_5D. Again a new terminology is required. These seven forms of benzene are called: benzene, deutero-benzene, benzene-d_2, benzene-d_3, etc.

The deuterium atom has, of course, the same valence as that of the protium atom, but the mass ratio is 2:1.

This large comparative difference of mass provides a splendid opportunity for investigating the "mass effect" in chemical combinations. Never before have chemists had at their disposal two atoms so nearly alike in structure and with masses so widely different on a comparative scale. In the isotopes of other elements the mass ratio is too small to give noticeable differences in the mechanism of reactions.

The isotopes of hydrogen will permit the chemist to follow, to a certain extent, individual atoms as they are attached to various chemical compounds. Urey has suggested that "in many cases it should be possible to introduce a deuterium atom in some part of a complicated organic compound and then follow this atom in subsequent chemical reactions. It is, in fact, a 'tagged' atom which can be introduced into chemical compounds at one point and later identified after rather extensive changes have taken place."

Through the use of deuterium it may be possible to solve the two main problems in the study of reactions catalyzed by acids and bases: (1) the mechanism of change in the molecule, and (2) the function of the catalyst.

One of the most remarkable features of heavy water is the marked differences from ordinary water it shows in its chemical effects. The ion product for D_2O is about 2.5 times smaller than that for H_2O. A number of exchange reactions between deuterium oxide and other compounds have been studied. Ammonia exchanges very rapidly with heavy water to give ammonia in which H atoms are replaced by D atoms to an extent depending on the relative concentrations. In cane sugar, on the other hand, only about one-half the hydrogen atoms are replaced and these are the ones that are present in the sugar molecule as a part of hydroxyl groups. Acetylene and acetone do not give up their hydrogen for deuterium in acid solutions or in plain heavy water, but they do so more or less readily in basic solutions. In acetic acid, CH_3COOH, the acidic hydrogen is the atom most readily replaced.

Cane sugar is broken down by reaction with heavy water faster than by ordinary water. In other reactions the velocity is slowed. In nitroethane for example, the rate of neutralization in water is about 10 times greater than in deuterium oxide. The alcoholic fermentation of glucose in D_2O is about nine times slower than in plain water. The velocity of reaction between aluminum carbide and water to give methane is about 23 times as great as the reaction between heavy water and aluminum carbide to give deuteromethane. According to Lewis and Schutz, the large difference in vapor pressure between proto- and deutero- forms of such compounds as water and ammonia is almost entirely due to the greater strength of the D bond as compared with the H bond.

In Physics

In physics as in chemistry heavy hydrogen provides a powerful research tool. Here the physicist has a particle like the hydrogen atom except for a greater mass. The electronic structures of the two are the same. Theories concerning atomic and molecular structures can now be tested, for to be acceptable they must hold true for deuterium as well as for ordinary hydrogen. Spectroscopic observations of light and heavy water show that they have the same general molecular structure.

Preparation of Heavy Water

When a mixture of H_2O and D_2O is electrolyzed, the rate of decomposition of H_2O is about five times as great as that of D_2O. This means that the hydrogen gas evolved from an electrolytic solution that is equally rich in the two waters will contain five times as much protium as deuterium, and the residue will contain an increased concentration of D_2O. Of course, natural water does not contain heavy water in any such concentration. As we have stated, most natural waters contain D_2O to the extent only of about one part in 5,000, or about 0.02%, but if the electrolyzing is performed in stages and repeated often enough, almost any concentration of heavy water can be obtained.

Bruni and Strada, two European chemists, have demonstrated that D_2O can be separated from H_2O by successive fractional crystallizations (freezing) of one-fifth to one-fourth of the water. Nine steps of successive freezing and melting in this manner gave a solution containing 0.414% of D_2O. This work suggests a possible separation of D_2O in the natural freezing and thawing of lakes and streams.

Properties of Water and Heavy Water

PROPERTY	WATER	HEAVY WATER
Density	0.9982	1.1079
Refractive Index	1.33293	1.3281
Molar Refraction	3.711	3.677
Viscosity	10.87	14.2
Surface Tension	72.75	67.8
Boiling Point	100.0°	101.42°
Melting Point	0.0°	3.8°
Heat of Fusion	80.02 cal. per gm.	76.1 cal. per gm.
Critical Temperature	374.2°	371.5°
Magnetic Susceptibility	−0.72	−0.65

Specific heat for water and for heavy water is the same.

The solubility of salts is less in D_2O than in H_2O.

Conduction in electrolytes is less in D_2O than in H_2O.

Tritium Oxide

In 1934, Rutherford suggested that the bombardment of deuterons with deuterons should produce a new hydrogen isotope of mass 3. Since then the experiment has been tried. It resulted in the formation of a third isotope of hydrogen which is present in deuterium to the extent of one part in 5,000. The new isotope is called *tritium*.

Investigators at Princeton University have found

Continued on Page One Hundred and Sixteen

Preserving Botanical Materials

● By Elbert Voss, Ph.D., *(University of Florida)*
DEPARTMENT OF BOTANY, DUQUESNE UNIVERSITY

This paper gives at least one practical solution of the problem of what to do when money is scarce and materials for botanical study may not be purchased. Many teachers would be willing to do the work of preserving botanical specimens if they knew how to proceed. Here are directions for the work.

Some of the simpler methods of preserving plant specimens very nearly in their natural state are discussed.

Dr. Voss offers some interesting suggestions.

●

If botany is to be presented to high school students as effectively as it can be and should be, ample supplies of plant material for study and demonstration should always be on hand. Whenever possible, the pupil should actually see and handle the things he reads about in his textbook. The purchase of such materials is sometimes not permitted by the science budget. There is a way around the difficulty.

Much material suitable for class use is to be found in home gardens, fields, forests, ponds, and streams during the spring, summer, and early fall. It can be collected during the proper season and preserved until it is needed if the teacher knows how to do the work and can spare the time to do it. The procedures are not especially difficult, but they do require time and patience. Different kinds of plants require different methods of preservation. For some specimens special treatment is necessary in order to bring out their hidden characteristics. The botany teacher should know what kind of specimens to collect, where to get them, and how to prepare and preserve them. The purpose of this paper is to describe a few of the simpler methods for treating botanical materials so that they may be kept for considerable periods of time and still be in good condition for classroom use.

To be comprehensive enough to meet fully the needs of the teacher of high school botany, a paper on this subject should include methods of collecting, mounting, and preserving plant materials in the dry state. This part of the work was discussed by Harold W. Werner in the June, 1935, issue of the SCIENCE COUNSELOR (Developing an Herbarium). It will not be repeated here. We shall consider certain other phases of the work, such as the preserving of plants in liquids in such a way that they remain very nearly in their natural state; a method for staining and demonstrating the vascular systems in small plants and fruits; and a method for growing fern gametophytes. Certain other aids for the teacher of botany may be discussed in a later paper.

Equipment

Work of this kind requires chemicals and equipment, but neither of these need be costly. Most of the chemicals used are not very expensive. Much of the apparatus can be improvised. Probably no one teacher will attempt to do in a single term all of the things we are about to suggest. They should rather be made a part of a far-reaching program that will not draw too heavily at any one time upon the teacher's leisure or the financial resources of the school. The home kitchen and the high school chemistry laboratory will supply much of the apparatus required. Specimen jars of uniform size and appearance are desirable. They do not cost much. If they may not be purchased, wide-mouthed bottles of any convenient size can be used. Pickle and olive bottles, glass fruit cans, and the glass bottles in which chemicals are bought, all make usable, make-shift containers.

Preserving in Liquids

The following methods may be used for flowers, delicate plants, and fruits. The "universal" preserving agent is a mixture of equal parts of denatured alcohol and water to which about four per cent of formalin is added (Formula No. 1). Diluted alcohol alone of this strength will keep plant materials from decomposing, but it has a shrinking effect that in most cases is objectionable. Formalin is added to lessen the shrinking effect of alcohol, which it does to some extent. This inexpensive solution is satisfactory for preserving specimens that are to be used for demonstrating morphological types. Its plasmolytic properties make it suitable for materials that possess natural firmness. In the case of exceedingly delicate materials, however, the amount of plasmolysis would make its use inadvisable.

This solution is not wholly satisfactory for several other reasons. It does not preserve natural colors. Formaldehyde is volatile and evaporates readily. If the container is opened frequently, the solution becomes weak. An additional disadvantage is that, while they are being used, the specimens have the objectionable odor of formaldehyde. This can be counteracted to a considerable extent by soaking the preserved material over night in dilute ammonia water.

A simple modification of the formula just discussed gives a solution that not only is a better preservative, but one that also fixes natural colors. Acetic acid is added for this purpose. Glycerin is present to lessen the volatility of the formaldehyde. The modified formula is as follows:

Formula No. 2.

Diluted ethyl alcohol (50%)	90.0 cc.
Formalin (solution of formaldehyde)	5.0 cc.
Glacial acetic acid	2.5 cc.
Glycerin	2.5 cc.
Total	100.0 cc.

If glacial acetic acid is not at hand, 7 cc. of 36 per

cent acetic acid, or a corresponding amount of acid of another strength, may be used to replace the 2.5 cc. of glacial acetic acid required.

On long standing, certain chemical reactions take place in the solution. Part of the alcohol is transformed into ethyl acetate. For this reason it is necessary every six months to add about 1.3 cc. of glacial acetic acid to every 100 cc. of solution.

This formula produces a clear, iridescent solution which does not have the disadvantages of the first solution. It is preferred for very delicate plants. Materials killed in it retain their shapes well and can be transferred easily from one jar to another. They should be left in this solution for from three to ten days. They may then be transferred to another preservative or left in this solution indefinitely.

Salts of uranium and copper aid in preserving the chlorophyll color. When 10 gm. of copper chloride and 1.5 gm. of uranium nitrate are added to each 100 cc. of solution made by Formula No. 2, the green color of plants is satisfactorily retained. This modified solution should be used for highly colored specimens. When blue-green algae are to be preserved, the substitution of 10 gm. of copper acetate for a like amount of copper chloride is recommended. For yellowish-green plants a 50 per cent reduction in the amount of copper chloride is desirable.

Fisk and Addoms* recommend this color-fixing solution:

Formula No. 3.

Acetic acid, 50%	500 cc.
Cupric acetate, enough to form a saturated solution, about	15 gm.

"For use with seed plants this solution may be diluted with an equal amount of water. Heat the solution to boiling and plunge in the material to be fixed. The green color will change to yellow, then to bluish-green. Remove the material as soon as the green color returns, place in water for half an hour, then preserve in formalin alcohol. . . . A most satisfactory color-fixing solution."

Vascular Systems

If plant stems are cut under water in which a suitable stain has been dissolved, the stain rises in the bundles making them very promiment when the material is subsequently dehydrated and cleared. Basic fuchsin is the stain commonly used. The following solution is a satisfactory one:

Formula No. 4.

Basic fuchsin	0.050 gm.
Alcohol, 95%	2.0 cc.
Water, enough to make	100.0 cc

The top six inches of old or young plants, such as tomatoes or beans, are cut off. This causes a more rapid translocation of fluid from the tip of the plant and hastens the passage of staining solution. The plants are lifted from the soil, and the roots are washed free from adhering material. The root system is immersed in the stain, and a portion is cut off beneath the surface of the solution. In 24 to 48 hours the vascular bundles will be well stained. Dehydration follows.

In carrying out the dehydrating process, the stained plants are placed successively in a series of containers of alcohol of 50, 60, 70, 85, 95, and 100 per cent strengths, allowing them to stand at least 12 hours in each container. A good practice is to change them once a day. With large pieces this longer standing is essential. The dehydrated material is cleared by immersing it in a series of solutions made of (1) 75% absolute alcohol and 25% xylol; (2) 50% each absolute alcohol and xylol; (3) 25% absolute alcohol and 75% xylol; and (4) pure xylol, in which the material is kept permanently. It is permitted to remain 24 hours in each of the first three solutions.

The material is now ready for study. Cedar oil or carbon disulfide, to the extent of about one-tenth the volume of xylol, may be added to the xylol to prevent its too rapid evaporation. When the treated plant material is placed in a glass dish having a smooth bottom, with an electric light bulb underneath it, the vascular system can be traced in great detail.

Small fruits can be studied in this way. If they are kept in the xylol-carbon disulfide mixture in glass-stoppered, wide-mouth bottles, they may be preserved for years. Sections of apple, either longitudinal or transverse, about 3 to 4 mm. thick, stain well. Strawberries and gooseberries make interesting and beautiful specimens.

Growing Fern Prothallia

Pack a clean, porous flower pot full of moist sphagnum. Wet the outside of the pot. Then invert it in a pan of water. Sow the spores on the surface of the pot and cover it with a bell jar. No further wetting will be necessary if the water in the pan is not permitted to dry up. Prothallia with gametes will appear within a few weeks, the time taken depending upon the species of fern being propagated. If spores of *Osmundi regalis* are sown in the spring, prothallia will be well developed by fall.

A nutrient solution may be used instead of plain water. The sphagnum may be sterilized before use. Sterilization is accomplished by placing sphagnum in ordinary finger bowls, covering it with water, and boiling the water. The bowls are kept covered during this process, as well as after inoculation with fern spores. They should be kept in a cool, moist place.

A good nutrient solution is made by the following formula:

Formula No. 5.

Solution A—	
Potassium Nitrate	1.0 gm.
Basic Potasium Phosphate	1.0 gm.
Magnesium Sulfate	1.0 gm.
Distilled water	1000.0 cc.
Solution B—	
Calcium Nitrate	2.5 gm.
Distilled water	1000.0 cc.

When the nutrient solution is to be used, mix equal

Continued on Page One Hundred and Twenty-four

*A Laboratory Manual of General Botany. Fisk and Addoms. Macmillan.

Steps Forward

Continued from Page Ninety-five

Parish Schools for the Diocese of Pittsburgh, Rev. Paul E. Campbell, will speak. Rev. J. J. Callahan, C.S.Sp., President of Duquesne University, will welcome the visiting teachers. Hugh C. Muldoon, Director of the Conference, will preside.

One of the chief addresses of the meeting will be made by Dr. James N. Rule, former State Superintendent of Public Instruction of Pennsylvania. An important feature will be an address which will be given by Rev. John M. Cooper, professor of anthropology at Catholic University. Father Cooper is well known as a scientist. He is one of the founders of the rapidly spreading Catholic Round Table of Science. Demonstrations in science, and three round-table discussions will be a part of the program. The latest textbooks in high school science and new scientific apparatus will be exhibited. An interesting and valuable part of the Conference will be a display of student projects in science supplied by various Catholic high schools. The loan of material for this exhibition is requested in another place in this issue of the SCIENCE COUNSELOR.

There is no registration fee or charge of any kind in connection with the Conference. Those in attendance will be the guests of the University at lunch. Visiting teachers will be cared for by the Sisters' Alumnae of Duquesne University under the leadership of Sister M. Aurelia Arenth, O.S.F., President. Members of the Sisters' Alumnae will act as hostesses and guides. They will serve tea during the social hour that concludes the program for the day.

The Sisters' Alumnae will provide accommodations for all visiting Sisters. Reservations may be made by addressing Sister M. Aurelia Arenth at St. Wendelin's Convent, Custer avenue, Pittsburgh. A large number of teachers will be in attendance. Those who come from considerable distances will find it desirable to make reservations well in advance of the Conference.

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SCIENCE PROJECTS WANTED

Teachers are always interested in the work done and the teaching methods employed by instructors in other schools. Teachers of science may be greatly aided by studying the student projects that have been found workable and useful by other teachers. An exchange of ideas is helpful and productive of good. Duquesne University, therefore, invites teachers everywhere to select some of the more successful science project material they have used or developed and submit it for display at the Science Conference on February 20, 1937.

The projects submitted need not be original; neither need they necessarily be elaborate or expensive. They may be in the form of home-made apparatus, collected materials, herbaria, specimens, displays, teaching devices, models, carvings, drawings, photographic work, special charts, etc. They may be connected with any high school science. Displays at other Conferences have included everything from models of teeth carved from soap to home-made telescopes; from a collection of butterflies to a series of instructional charts. Pictures of some of these have appeared in the SCIENCE COUNSELOR. Photographs will be made of the most interesting projects displayed at the coming meeting.

Please send in a display even if you are unable to be in attendance. In order to display your projects it is not necessary that you or any member of your science staff shall attend the Conference. Regardless of where your school is located, this is an opportunity for *you* to help other teachers of science. *Will you do it?*

Each display should be labeled with the full name and address of the school, the name of the teacher, and the name of the student. They should be addressed to the Director of the Science Conference, Duquesne University, Pittsburgh, Pa., and shipped so that they will arrive on or before February 15, 1937.

All project material will be returned, carriage paid, to the cooperating schools after the Conference.

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High School Course-Physics

Continued from Page One Hundred and Four

In other words, the deductive part of scientific reasoning is to be brought into play. Since, in the solution of problems in later life, one of the very important factors is to find the particular principles that will apply to the problem at hand, it is essential that the problems that are given in the course as typical ones on which the student may test his skill, should not be grouped according to the principles that are needed in the solution. If this mistake is made and a group of problems is given as an exercise after a principle has been learned, which problems may be solved by the application of that particular principle, then half, and the more important half of the work, is already done for the student. In this way one of the goals of the course is not attained. It is a rather common thing to find that problems are arranged in exactly this way in high school texts.

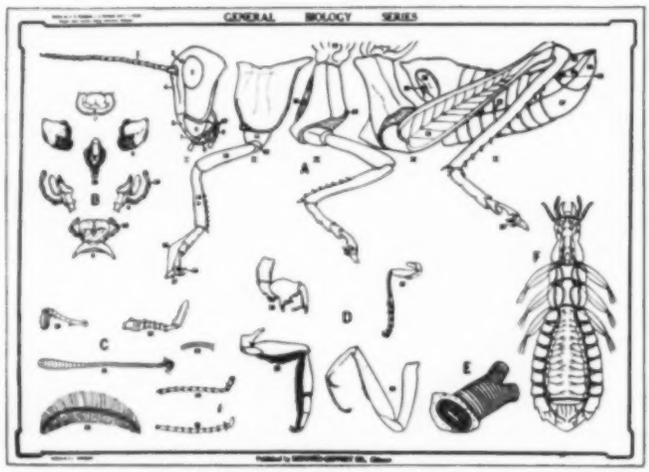
Textbook

At this point we might consider the qualifications to be sought in a physics textbook. Of course, it is understood that one of the serious difficulties to be encountered in this matter is the fact that in many instances the State Board of Education or the particular accrediting agency under which our schools operate, and with whose regulations we must comply, specifies one or more texts to be used as standards for the various courses in the high school curriculum. If this be the case there is little or no choice left to the teacher. But if the matter is in the hands of the teacher, then he should consider, in selecting a text, that one of his goals is to teach the fundamental principles of the science and not the almost innumerable facts, which are found to clutter up so many of our modern text books.

In determining which principles are the most important or fundamental, we ought to consider among other things the locality in which we are placed. If, for example, the majority of the students in the school come from farms, then the teacher should lay stress on those principles which find their application in farming and the use of farm machnery. If, on the other hand, the larger portion of the student body may be expected to spend their post-school days in a factory, then a different set of principles, or at least, some different principles, will be found to be of more value.

These, then, are the goals, the aims and objectives of the high school course in physics. The teacher of physics ought to keep these aims before him as he teaches his class, so that his work may bear fruit later in the lives of his pupils. It is suggested, that since it very often happens that science courses are not popular with students, it might be helpful to point out these aims not only at the beginning of the course, but also occasionally as the course progresses. In this way the student can be brought to realize that what he is doing now will have great value in after years; thus he will feel that all his effort is not in vain.

GENERAL BIOLOGY CHARTS



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Visual Aids

Continued from Page One Hundred and One

able to furnish gratis (express prepaid by the user), or for a low rental.

Good Visual Aids

"Just how should I know what is good as a visual aid and what is poor?" one may ask. The following is a list of criteria which may be used for this purpose. (1) A visual aid must be clear and to the point. It must not confuse the issue by drawing attention from the fact or principle to itself. (2) A proper visual aid should yield to specific planning in the teacher's routine; it must have a definite purpose, serving to illustrate definitely some principle or fact; it must be adaptable to the kind of pupil with whom the teacher works. To show a film, or portray an exhibit, model or chart because it is a clever representation of the real, or because it may be interesting to the pupils, is to acknowledge to the pupils a false sense of value. (3) A visual aid should be of such a size and be so arranged that it may be seen by the entire class. Examples are too frequently found in which a chart or a model is too small to be seen clearly by all present, or it has been so placed that, to see it, some in the rear of the classroom must stand. (4) A good visual aid most often expresses an advancement or progression within itself. Movies, slides and exhibits usually have an

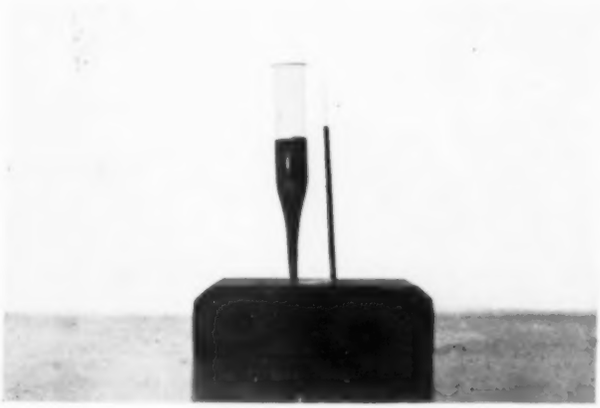

FIGURE 3

A TEST TUBE CONVERTED TO SHOW CAPILLARITY.

advantage in this respect over any other forms of visual aid. However, it is possible to obtain some charts which contain action either in picture, symbol or word. (5) A visual aid, to be effective, should be exhibited only as long as, and when it may serve its useful purpose. (6) Visual aids are most effective if distributed evenly throughout the period of advancement in the subject.

Visual education is in its infancy; much has been attempted, yet much has been left undone. Each teacher must be his or her own judge as to the merits and uses of these aids. The time is ripe; the "ore" is plentiful, so "stake your claim."

Listed below are recent materials and information obtainable gratis. In writing for them, it is highly advisable to use school stationery; some companies require it. The list given is merely suggestive.

CHARTS

Edison Battery: The Thomas A. Edison Company, Storage Battery Division, West Orange, New Jersey.
A 22"x14" chart shows a cutaway view of the Edison Cell.

Exide Storage Battery: Electric Storage Battery Company, Philadelphia, Pa.
This chart 73"x44", with wood ends, shows (1) the separate parts of an Exide Battery and (2) the chemical reactions during charging and discharging. Only one will be sent to each school. Excellent.

Laboratory Emergency Chart: Fisher Scientific Company, Pittsburgh, Pa.
A fine 24"x19" chart for a place on the laboratory wall or door, showing what to do in case of any kind of accident.

Orthopedic Shoes, Incorporated, 9-11 East 73rd street, New York, N. Y.
Five 27"x20" colored charts of the care of the feet, indications of foot trouble, results of foot trouble. Good for general science or hygiene. Might be used in connection with Center of Gravity in physics.

Refrigeration Cycle: Copeland Refrigeration Corporation, Mount Clemens, Mich.
In a 21"x16" chart there are shown in colors the essential stages in refrigeration. Variation of coloring within the pipes indicates the change of state, as of gas to liquid.

Ruud Manufacturing Company, Pittsburgh, Pa.
Furnishes two colored charts, 28"x17", one showing a cutaway view of the Rudd Automatic Hot Water Storage Tank, the other the unit in the Rudd Automatic Hot Water Heater.

The Microscope: Bausch & Lomb Optical Company, Rochester, N. Y.
In a 37"x27" colored chart there is shown the diagramatic construction of a microscope with the path of light rays.

United States Industrial Alcohol Company, 60 East 42nd St., New York, N. Y.
One chart, 21"x19", shows the steps in the manufacture and distribution of industrial alcohol. A second chart, 17"x11", shows the important uses of industrial alcohol.

Useful Birds: Church and Dwight, 70 Pine St., New York, N. Y.
Two 27"x20" charts of common useful birds, in color. Also, the same company will furnish separate colored pictures, 15"x11", of some other birds.

Uses of Zinc: New Jersey Zinc Sales Company, 160 Front St., New York, N. Y.
This chart, 22"x14", shows the many uses of zinc in commerce and in the laboratory. On the wall it is not large enough to be seen by all the class. Useful for individual inspection.

The Singer Sewing Machine Company, New York, N. Y., will furnish for 4-H directors, Scout Leaders, or Biology Teachers sets of common birds, in color.

DISPLAYS

Eastman Kodak Company, Rochester, N. Y.
Will loan for two weeks, gratis, a large chart on which are the actual materials used to produce film; or they will send, gratis, these same materials to be assembled at the school, to be a permanent possession of that school.

Educational Exhibit: Russia Cement Company, Gloucester, Mass.
Various grades of fish skin, and different stages in the manufacture of LePage's glue are shown as well as the types of glues produced. Good.

Educational Exhibit: The Carborundum Company, Niagara Falls, N. Y.
An excellent display, containing four bottles of the raw materials which are mixed and put into the electric furnace to produce Carborundum. Included also is a piece of Carborundum as it comes from the furnace, a small Carborundum stone, and explanatory literature.

Evolution of a "Mirro' Aluminum Clothes Sprinkler: Aluminum Goods Manufacturing Company, Manitoc, Wis.
In a series of about a dozen steps is shown how this particular aluminum article is produced. Also included are two small bottles of raw materials, a small bar of the molded aluminum, and literature. Good.

Firestone Rubber Company, Advertising Department, Akron, Ohio.
A small cardboard display of the Gum-Dipping process accompanied by suitable literature.

Various rubber companies can supply exhibits from time to time, either gratis, for loan, or at a low cost.

MISCELLANEOUS

General Electric Calendar: General Electric Company, 1 River Road, Schenectady, N. Y.
Colored pictures vividly portray some modern uses of electricity.

General Electric News Bulletin: General Electric Company, 1 River Road, Schenectady, N. Y.
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minute scientific news. Excellent for physics classes or general science.

The Society for Visual Education, 327 South LaSalle St., Chicago, Ill. If an appropriate projector is available, this society can furnish, gratis, film slides. Catalogues of both film slides and moving pictures will be sent upon request.

United States Bureau of Mines, Experiment Station, Pittsburgh, Pa. Will send either 35mm or 16mm films, express collect, on worthwhile subjects, the names of which may be obtained on request.

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Heavy Hydrogen and Water

Continued from Page One Hundred and Ten

that tritium oxide (T_2O) is present in heavy water to the extent of one part in 200,000. Since D_2O is found in natural water to the extent of one part in 5,000, the concentration of T_2O in natural water is about one part in one billion. It is theoretically possible to separate T_2O from D_2O in much the same way that D_2O is separated from H_2O. The cost, however, is prohibitive. It would be about $1,000,000 per gram.

Until 1932 it was generally believed that we had but one kind of water, H_2O. Now we know that there can be at least six, H_2O, D_2O, T_2O, HDO, HTO, and DTO, without counting the added number that are possible by using O^{18}.

Conclusion

The statements in this paper represent only a brief outline or summary of the present state of knowledge

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concerning heavy water. They have been compiled from all the available literature. Authors and references have not been cited since the bibliography alone would require too much space. By the time this paper is published, new and interesting facts concerning heavy water not included here will probably have been revealed.

◆

The Aquarium

Continued from Page Ninety-eight

ium may be permitted to go for great lengths of time without changing the water, but water must be added from time to time to make up for the loss by evaporation. At present we have three aquariums that have been set up for more than five years. They are nearly as clean as the day they were planted.

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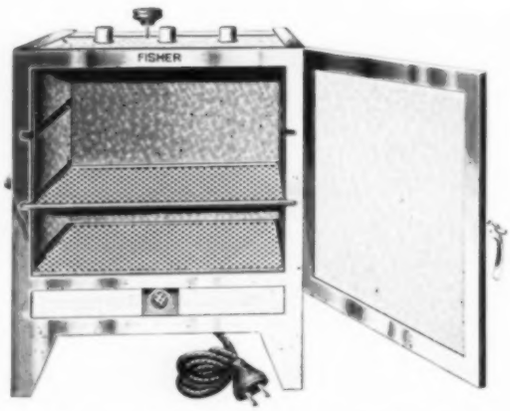
Our pupils were very much interested last April when we noticed that one of our goldfish was beginning to spawn. Within a few days many hundreds of tiny round eggs were deposited. We watched the female very closely. When she started to eat the eggs, she was removed to another tank. The male was permitted to remain a little longer to insure fertilization.

The development of the eggs was watched with care. Some of them soon turned white, indicating that they had spoiled. Most of them, however, remained transparent. They had been fertilized, and were beginning to develop. We followed the changes in them with magnifying glass and microscope until the fifth day, when the eggs began to hatch. The fry were about a quarter of an inch long and as slender as a hair. The two large eyes seemed greatly out of proportion to the rest of the body and gave the tiny fish an odd appearance. On their ventral surface we found the yolk mass that is used for food during the first five days. After the fifth day we fed them daphnia, egg yolk, and pulverized puppy biscuit. This diet proved to be satisfactory for the first two months. Then we used common fish food, finely powdered. At this stage of their development we began to distribute the young fish among the members of the class, keeping enough of them at school so that we could watch their further growth and development.

This experience was especially interesting since many people believe that fish cannot be hatched and grown in an aquarium. We did notice, however, that the fish which were placed in an outside pool developed fully twice as fast as those that were kept in the aquarium.



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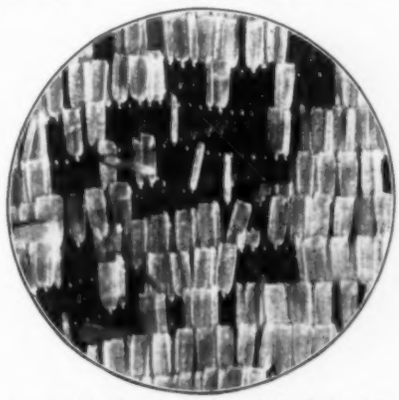

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Lakeview Station

Science Night

Continued from Page Ninety-nine

that they may not be present during the evening unless accompanied by their parents.

The commercial department of the school can furnish mimeographed programs. Their pupils can serve as traffic counters to determine the number and type of people attending.

Educational Value

The chief idea in undertaking a Science Night is to endeavor to interest as many students as possible in the showing of classroom material to as many classmates, parents, relatives, and the general public as they can. The training received by a student who is able to show and explain something in which he is interested to such an audience, is hard to estimate. He gains experience beyond anything possible in ordinary class-room routine. He develops confidence in his ability, a realization of the necessity for complete understanding of his project, and the feeling of importance that comes from being assigned to a place of responsibility in the eyes of his classmates and the public. He has the satisfaction of accomplishing something worth-while. All these points are difficult to measure, but they are highly important in the education of youth.

To attempt to discuss in detail the many exhibits possible, would require more space than this article will permit, but we have learned that the departments of Art, Biology, Astronomy, Mathematics, Physics, Psychology, Chemistry, Latin, Library, Home Economics, Newswriting, English, French, Spanish, Bookkeeping, Clothing, Auto Mechanics, and, in fact, every department of the school, can do its bit toward a successful open house. The tendency in each department is, of course, for the teacher to place his better students in charge of exhibits, but in an undertaking of this sort, each department must be willing to yield to other departments, whenever a deeper interest of the student may be involved. This is a function of the Central Clearing Committee.

We should mention, perhaps, that the present emphasis on consumer education finds a splendid outlet in a Science Night. It draws tremendous interest from patrons of the school. This department must be carefully handled to prevent unfavorable comment from those who find that their products are not favorably compared. Many times it may be best to remove all traces of commercial labels from products before display, in order to avoid any appearance of advertising.

Training in proper buying is a subject that has been long neglected in our schools and one in which parents especially have considerable interest because their own training is weak along this line. Excellent material on this subject can be obtained from the *Consumer's Guide*, published by the Agricultural Adjustment Administration. Emphasis can be placed on such information as the capacity of various sized cans, which, while apparently identical in size, may increase the cost of food as much as 50%; methods of reading labels on cans, learning whether or not labels indicate the true story of the contents of a can, and studying slack-filled packages. These are all vital subjects.

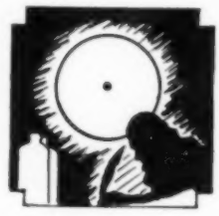
Besides exhibits definitely related to class-room activities, recreational displays can be devised. Music from the school musical groups is always enjoyed. Motion pictures on educational and instructional subjects can be shown, and addresses by well-known speakers on popular scientific subjects prove of interest.

A high tension electrical display by someone qualified to handle the many technical electrical devices of our modern day is always interesting. In past years we have secured the services of a glass blowing expert, who was able to cleverly produce many attractive articles from glass before the eyes of the visitors. This always is of interest to our patrons.

Another possibility for a Science Night is the display of interesting hobbies of students in the school. It is not very difficult to secure an exhibit of such material. Many students are extremely talented along lines entirely foreign to their usual school work and they very seldom have an opportunity to display their talent. In the past we have had exhibits of poetry, stamps, outing equipment, Indian handcraft, arrowheads, miniature aeroplanes, butterflies, and archery. In fact, any hobby will find a place in an exhibit of this type. Students like to display to their friends the things in which they are vitally interested.

Every department in the school can find its proper place in the development of an open house night. Only the departments whose teachers lack initiative and willingness to cooperate are absent from such an open house.

A proper Science Night, then, will interest the entire community in the activities of the school, and will attract in great numbers people who would be unwilling to attend a lecture or series of talks such as are normally given in the average school. These meetings have definite educational value for every boy and girl who cooperates in the undertaking. They also "sell the school" to its patrons and thus secure greater interest in every activity in the school.



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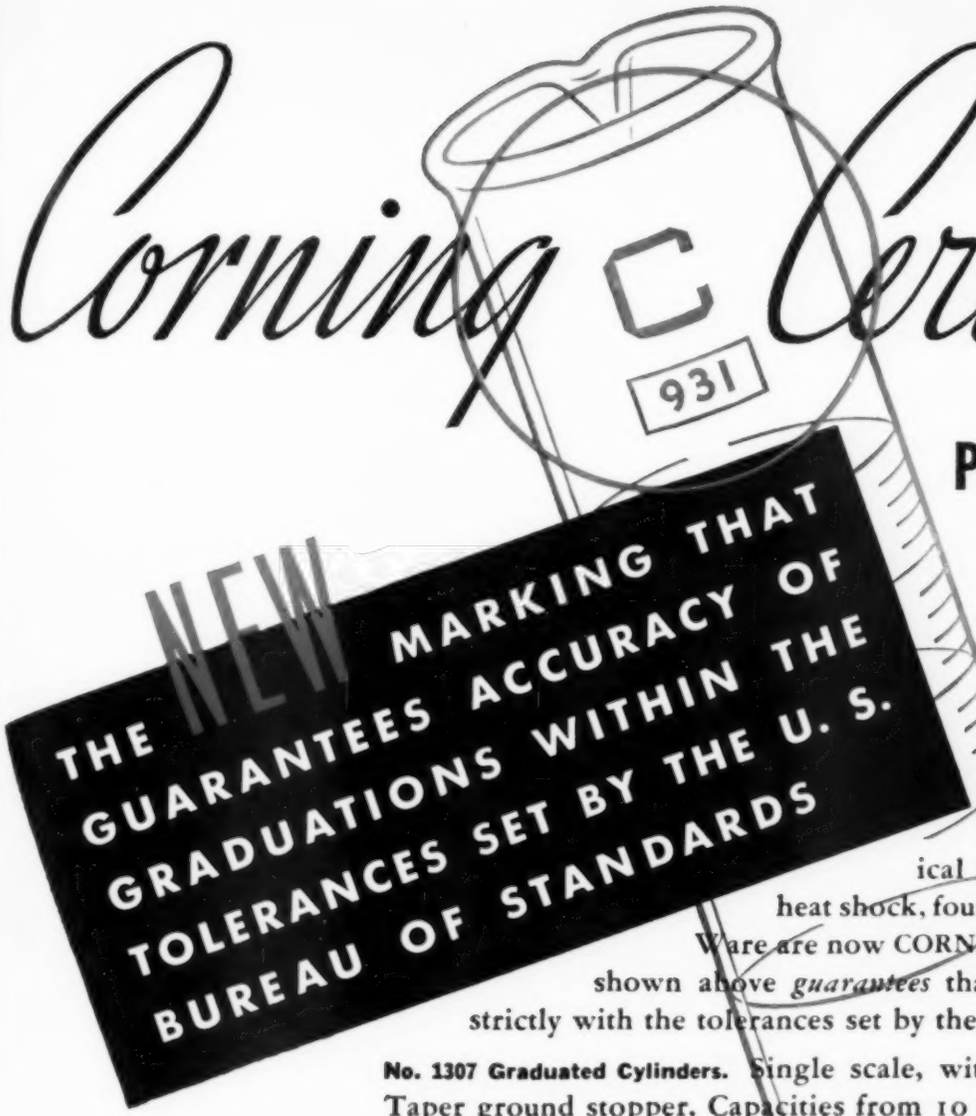

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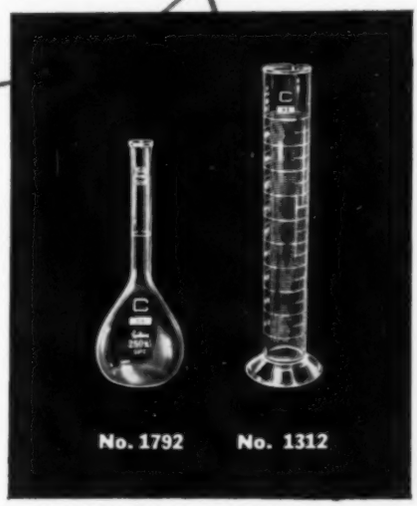

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The Physical World

●*By* LOUIS M. HEIL, Associate Professor of Electrical Engineering and Physics, Ohio University; Philadelphia, P. Blakiston's Son & Co., Inc., 1936. ix + 566 pp. $2.75.

This book is adapted for those who do not intend to take up science as a major study, but who nevertheless wish to acquire a general knowledge of physical science.

Designed primarily as a textbook for a "cultural" course, this book will be welcomed by a large number of colleges and universities where such courses are now being given and where the choice of a suitable textbook has been a problem. To use the words of the author: "After all, the students of journalism, English, the classics, are not going to spend their time making numerical solutions but, instead, they want to know something about the physical world in which they live."

The subject matter of this book is presented in a descriptive manner, and mathematical analysis is, in general, avoided. The author succeeds in giving a description of physics which is non-mathematical, yet accurate and exact—a feat not easily accomplished.

Beginning with a brief history of the development of physical science, the author takes up in order, astronomy, concepts of matter, mechanics, molecular motion, heat, sound, electricity, light and modern physics. Chemistry is injected where needed. The many illustrations are interesting and clarifying. The subject matter is broad, including descriptions varying from the macroscopic structure of the universe to the intricate microscopic structure of the atom.

Each chapter in the book is supplemented by references to other books and to readable journals. It can be well recommended as a reference book in physics, and should prove to be interesting reading to those who wish to get a general knowledge of physics without wading through abstract and technical treatises on the subject.

R. S.

●

Elements of Psychology

●*By* KNIGHT DUNLAP, Professor of Psychology, University of California at Los Angeles; St. Louis; The C. V. Mosby Company, 1935. 499 pp. 65 illustrations. $3.00.

Psychology in recent years has undergone many radical changes, so many in fact, that it is almost impossible to keep up with them. Many new theories have been advanced, some with scientific proof and some without it. Some of these theories have wandered far afield in their attempts to please the crowd and to lower the findings of psychology to the level of the ordinary layman. Lately, however, due to a great extent to the experimentalists in the field of psychology, and to workers in the field of psychiatry, the publications tend to have a more solid basis and foundation.

Dr. Dunlap's book is a typical exposition of this fact. This is quite evident from the index of the chapters alone. He has deleted much of the "rubbish" which is usually found in texts of this kind. The logical sequence of thought evidenced throughout the whole book is very refreshing to persons who have been accustomed to correct thinking and have become surfeited with the ramblings of many modern writers.

The spirit of the book may be summed up in the following quotation from Dr. Dunlap's preface:

> "I have not attempted to prepare easy steps for little feet. There is a plentitude of books which are available to those who wish a text of that sort. I have attempted to write a book which shall be worth serious study and which should repay the labor of which the average undergraduate is capable. If it should turn out to be suitable for the student unwilling to work or of dull understanding, I should be deeply disappointed for such a book is necessarily a failure. I have sought for clarity and precision rather than simplicity and have included deliberately much repetition."

Rev. Raymond V. Kirk, C.S.Sp., Ph.D.,
Duquesne University.

●

New Practical Chemistry

●*By* NEWTON H. BLACK, Assistant Professor of Physics, Harvard University, and James Bryant, President, Harvard University. New York, The Macmillan Company, 1936; x + 621. Illustrated. $1.80.

Black and Conant have prepared a textbook that should appeal to high school students as well as to high school teachers. It is scientifically and pedagogically sound. It is up-to-date. Written in a simple and direct manner, this textbook should stimulate in the pupils a keen interest and a curiosity about the everyday things with which they come in contact. It will provide a good foundation for the further study of chemistry.

The book is attractive in appearance, well bound and well printed. Several color plates are included among the illustrations.

Numerous helps for teacher and student are listed. Individual differences have been considered. The book contains thirty-six chapters. It is not arranged on the unit plan.

Teachers who contemplate a change of text should examine this book carefully. *H. C. M.*

●

Social Biology

●*By* EVERETT P. WALTON, A.B., and PHILIP E. FOSS, A.M., of the Biology Department, Public High School, Hartford, Conn. Philadelphia, P. Blakiston's Son & Co., Inc. 1936; xv + 572. Illustrated. $1.68.

Well written, well printed, strongly bound, and containing 360 informative illustrations, this textbook for secondary schools should prove to be both attrac.ive and practical. The authors are experienced teachers of biology. They believe that when the horse is led to water, the water should be made to appear so inviting that the horse will want to drink. They have been suc-

Continued on Page One Hundred and Twenty-four

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Continued from Page One Hundred and Twenty-two

cessful in making their book so interesting that it will be easy for the student to study from it.

The fifty-two chapters of the book are grouped into thirteen well arranged units. Numerous teacher and pupil helps, such as review questions, self-testing exercises, word lists, and interesting projects, are included. An appendix contains a list of books suitable for study and supplementary reading. The index is very complete.

H.C.M.

●

Botanical Materials

Continued from Page One Hundred and Twelve

portions of the two solutions and add it to the sphagnum.

Collecting Fern Spores

Use pasteboard boxes with lids, such as ordinary shoe boxes. Line them with white paper. In each box lay three or four spore-bearing fern fronds and set aside for a few days. The fronds will shed their spores, which may be collected from the white paper and poured into bottles. A different kind of fern may be used in each box.

The spores thus collected are sown on the sphagnum in the bowls or placed on the bottom and sides of the flower pots containing sphagnum. Spores of *Osmunda regalis* and of other members of the genus must be sown as soon as ripe or they will fail to germinate. If carefully covered with glass, the prothallia may be kept alive and producing antheridia and archegonia for several months. They become quite large.

●

Selecting Chemicals

Continued from Page Ninety-six

Group III.	C.P. A.R. A.C.S.	Of "chemically pure," or analytical reagent grade. Refined in accordance with definite standards, e.g., those of the American Chemical Society. With presence of impurities quantitatively indicated (usually in the hundredths or thousandths of one per cent) on the label.

Between the first and third grades of the same chemical there may be a maximum price spread of several hundred per cent. A change in grade specifications, as from U.S.P. to C. P., may add much, or little, to the cost. In the case of mineral acids, for example, the price difference is insignificant. On the other hand, the cost of specifying Group III grades for all the chemicals on an average order may be high indeed, as much as 50 per cent or more.

This emphasizes the price that must be paid for the not infrequent, and not always defensible, injunction: "All chemicals must be C. P." Adherence to that specification is seldom economical, and sometimes impossible —in view of the fact that certain chemicals are not to be had in C. P. grade at any price. For the highest attainable degree of purity, there is a price premium which may add more to cost than to value.

●

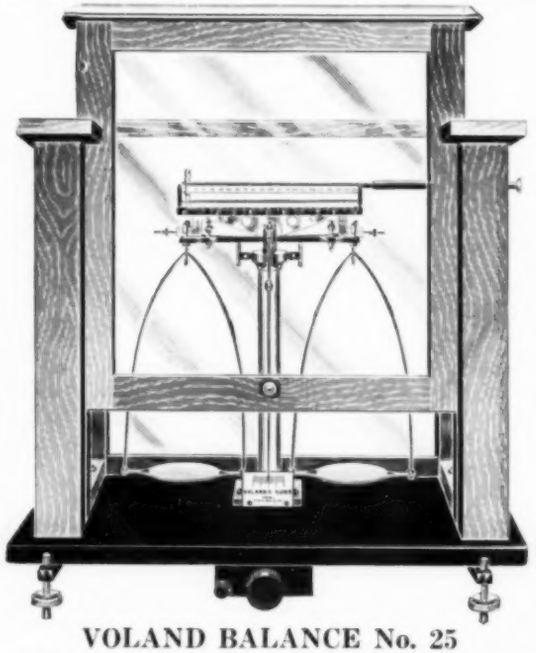
Roger Bacon. *Scientist*

Continued from Page One Hundred and Five

had the ability to write, and to teach what he knew. His important discoveries in light, his rectification of the errors in the calendar, and,—a most important achievement,—the use of the inductive method of experimentation, all clearly illustrate the amazing genius of the Franciscan friar.

He foresaw many future discoveries,—the aeroplane, the railway, the automobile — wonderful, almost unbelievable things, which were to be not the result of magic, to which most discoveries were then attributed, but rather as he said the product "of human art applied to the results of the study of natural events."

All the world is today aware of Roger Bacon. It admires and marvels at this man who worked a life time in an attempt to find out the truth about science. A truly great man—a scientist, philosopher and scholar that made him a worldly man; a humble, believing and devoted Franciscan friar that made him a religious man.



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